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Growth Rates of Some Ranids under Natural Conditions

RICHARD A. RYAN

THE growth rate of frogs under natural conditions has been little studied. The reports of Force (1933), Hamilton (1934), Raney and Ingram (1941), and Raney and Lachner (1947) have contributed to our knowledge of natural growth in the anurans. Wright's tables (1920, 1932) showing the growth rates of a number of species of anurans must, as the author states, be considered provisional. They are based largely on the arbitrary assignation of year groups presumptively determined for each species from measurements of specimens collected randomly over a period of years.

Raney and Ingram (1941) recorded the growth of six adults of *Rana clamitans* under natural conditions by marking individuals with jaw tags and obtaining the growth increment with each recapture. Force (1933) arrived at a growth rate for *Rana pipiens* in northern Michigan which approximated that determined by Wright (1920). Force collected large numbers of individuals in one day and arbitrarily assigned them to age groups based on size. By making a second collection somewhat later the growth increment for this period for a given age group was determined by subtracting the mode of the first from that of the second. From this figure an approximate weekly increase and an average seasonal increment were calculated. The species was found to begin breeding at three years of age. Growth of 10 to 11 mm. was shown for the first year following transformation, and 7 mm. for the second.

A study was begun in the spring of 1949 in the Ithaca, New York area to determine the rates of growth of the local species of ranid frogs under natural conditions. The investigation was continued through the spring of 1951. Using the method employed by Hamilton (*op. cit.*) and Raney and Ingram (*op. cit.*) in their studies of growth, individuals were marked, measured, and released at the place of capture. Increment in growth for the period between each capture was obtained by field measurements. Marking was begun each season when the frogs emerged from hibernation early in the spring, generally in late March, and continued until early November when most individuals had disappeared.

The frogs were marked by cutting off toes in various combinations; seldom was more than one toe removed from each foot. Some of the larger individuals were marked with jaw tags early in the study, but later this method was abandoned in favor of toe clipping. Jaw tags could be used only on large individuals and even then, unless carefully placed, they often caused inflammation and swelling that might interfere with feeding.

Study areas were selected that were small and somewhat isolated but which maintained considerable numbers of frogs. The small size and isolation of an area permitted the marking of most individuals and favored their recapture.

The total length (the distance from the tip of the snout to the end of the urostyle) was recorded in millimeters for each frog. The measurement was made three times at each capture and an average taken, if differences occurred. The greatest discrepancy, a millimeter at most, appeared in measurements of larger frogs. As a companion measurement the length of the tibia was also recorded.

Although nearly 1100 frogs of five species were marked, a sufficient number of recaptures to indicate growth rate was obtained for only three: *Rana clamitans*, *Rana pipiens*, and *Rana catesbeiana*. The total number of greenfrogs marked in 1949 and 1950 was 483, and of these 127 were recaptured. Four hundred and two leopardfrogs were marked in the same period; of these 44 were retaken. Thirty-five bullfrogs were recaptured from a total of 81 marked individuals. The growth records of individuals of each of these species (Tables I, II, and III) were selected on the basis of the interval between captures and the number of captures made. Many frogs were recaptured only once after an insignificant time interval. These growth records are not recorded here.

TABLE I

GROWTH RECORDS OF 41 INDIVIDUALS OF *Rana clamitans* IN THE ITHACA, NEW YORK AREA IN 1949 AND 1950

Specimen No.	Sex	Total length, in mm.	Date
2 SM	..	44	Apr. 27, 1949
		73	Sept. 16, 1949
		74	Apr. 27, 1950
33 GP	♂	69	Apr. 30, 1949
		76.5	Aug. 29, 1949
		77	Sept. 7, 1949
		77.5	May 3, 1950
		79	June 8, 1950
		80	June 23, 1950
4 VN	..	48	May 4, 1949
		57	July 9, 1949
11 SM	..	39.5	May 5, 1949
		46	June 10, 1949
		53	June 28, 1949
		55.5	July 9, 1949
		68	Sept. 16, 1949
		70	Oct. 13, 1949
7 GP	♂	69.5	May 8, 1949
		76	June 7, 1949
		79	July 1, 1949
		83	June 15, 1950
		84	July 13, 1950
		85	Aug. 7, 1950
8 VN	♀	74	May 13, 1949
		75	May 30, 1949
		80.5	May 10, 1950
22 SM	♂	43.5	May 15, 1949
		72	June 16, 1950
12 VN	♂	76	May 18, 1949
		86	June 16, 1950
		87	July 11, 1950
		87	July 25, 1950
107 VN	♂	90	June 5, 1949
		90.5	June 15, 1950
JT 832 GP	♀	83.5	June 7, 1949
		84	May 3, 1950
		89	June 15, 1950
		90.5	June 23, 1950
		90.5	July 14, 1950
		91.5	Aug. 23, 1950
		92	Sept. 26, 1950
		92	Oct. 30, 1950
JT 833 SM	♂	85.5	June 8, 1949
		88	June 26, 1950

TABLE I—*Continued*

Specimen No.	Sex	Total length, in mm.	Date
2 HW	..	44	June 10, 1949
		48.5	June 29, 1949
		57	Sept. 7, 1949
		58	Sept. 19, 1949
		69	June 15, 1950
		77.5	July 14, 1950
		80	Aug. 23, 1950
18 VN	..	33	June 25, 1949
		45	Aug. 1, 1949
		54	Sept. 2, 1949
		58	Sept. 21, 1949
		59	Oct. 4, 1949
22 VN	..	60	June 28, 1949
		72	Aug. 17, 1949
8 HW	..	38.5	June 29, 1949
		63	June 28, 1950
5 HW	♀	53.5	June 29, 1949
		65.5	Sept. 7, 1949
		67.5	Oct. 6, 1949
6 HW	..	55.5	June 29, 1949
		65	Oct. 6, 1949
		80	July 14, 1950
26 VN	..	41	Aug. 1, 1949
		76.5	Sept. 19, 1950
		77	Sept. 28, 1950
		77	Oct. 5, 1950
28 VN	♀	40	Aug. 15, 1949
		45	Sept. 6, 1949
		45	Oct. 6, 1949
		44	Oct. 20, 1949
		77.5	Sept. 29, 1950
31 VN	..	42	Aug. 15, 1949
		49	Oct. 13, 1949
32 VN	..	39.5	Aug. 15, 1949
		45	Oct. 6, 1949
		44	Oct. 13, 1949
35 VN	..	46.5	Aug. 17, 1949
		49	May 10, 1950
		64.5	July 14, 1950
37 VN	..	51	Aug. 17, 1949
		51.5	Aug. 26, 1949
		53	Sept. 2, 1949
		55	Sept. 21, 1949
		55.5	Oct. 6, 1949
51 SM	..	49.5	Aug. 21, 1949
		55	Oct. 13, 1949

TABLE I—*Continued*

Specimen No.	Sex	Total length, in mm.	Date
43 VN	♂	53	Sept. 2, 1949
		68	July 11, 1950
		73	Aug. 10, 1950
		73	Aug. 14, 1950
		78	Sept. 29, 1950
52 VN	..	38.5	Sept. 6, 1949
		46.5	June 15, 1950
110 SM	..	47	Sept. 16, 1949
		63	July 7, 1950
		78	Oct. 2, 1950
72 VN	..	50	Oct. 6, 1949
		80.5	Sept. 28, 1950
		81	Oct. 17, 1950
75 VN	♀	48	Oct. 13, 1949
		60.5	July 6, 1950
77 VN	..	42	Nov. 10, 1949
		41.5	May 10, 1950
		46	June 15, 1950
		70.5	Oct. 31, 1950
100 SM	..	39.5	May 14, 1950
		51	July 7, 1950
		57	Aug. 11, 1950
102 VN	..	26	June 13, 1950
		36	July 25, 1950
104 VN	♂	80.5	June 13, 1950
		81	July 17, 1950
25 GP	♀	70	June 15, 1950
		76.5	July 14, 1950
		78.5	Aug. 8, 1950
		81	Sept. 7, 1950
106 VN	♂	65	June 15, 1950
		69	July 11, 1950
		70	July 17, 1950
170 SM	♂	70.5	July 26, 1950
		78	Aug. 23, 1950
187 HB	♂	69.5	July 6, 1950
		79.5	Mar. 30, 1951
125 VN	..	64	July 17, 1950
		73	Sept. 7, 1950
		76	Oct. 10, 1950
142 VN	..	35	Aug. 14, 1950
		45	Sept. 24, 1950
154 VN	..	29.5	Aug. 29, 1950
		31.5	Sept. 7, 1950
		33	Sept. 12, 1950
		34	Oct. 2, 1950
168 VN	..	32	Sept. 12, 1950
		36.5	Nov. 2, 1950

GROWTH OF *Rana clamitans*

Wright's records (1914) for the Ithaca, New York area and observations made during this study, show that greenfrogs begin emerging from hibernation the last week in March or the first week in April. Most spawn in late May and early June, but eggs have been found as late as the second week in August. The eggs hatch three to five days after deposition, depending on water temperatures. The tadpole of this species presumably overwinters and transforms the following season generally in late June or early July. Individuals have been found transforming from May to late September. Ting's (1951) laboratory experiments suggest that greenfrog eggs laid early in the season could produce transformed individuals under natural conditions during the same season.

There is considerable variation in size at transformation. The range in total length in this area extends from 26 to 38 mm. From 41 specimens Wright (*op. cit.*) obtained a range in length of 28 to 38 mm., with an average of 32 mm. A few transformed frogs 26 mm. in length were collected during this study.

Many of the recaptured greenfrogs in every area were taken at the same point or a few feet from the place of initial capture. This was true even of frogs retaken over a year after they were marked. With few exceptions the frogs remained in the same pool, pond, or backwater through the season and from one season to the next.

From early spring emergence until the first or second week in May there is no measurable growth in the greenfrog regardless of time of emergence or size of the individual. Hamilton (1948) showed that greenfrogs will feed during cold spells during the summer but not in the mild weather of March and April, probably because of the lack of suitable food. This may explain in part the lack of growth early in the season. Nearly all of the growth takes place from mid-May to September; a few millimeters may be added from mid-September to the time of hibernation in October or early November. Those individuals that complete transformation in late June or early July grow rapidly. Individuals may add 7 to 10 mm. to their length in the first month following transformation, the same the second month, and 3 to 5 mm. in the first half of September. From the middle of September until hibernation, 1 to 2 mm. more may be added (Table I—frogs 18 VN, 28 VN, 154 VN). Those frogs that transform in late

TABLE II

GROWTH RECORDS OF 26 INDIVIDUALS OF *Rana pipiens* IN THE ITHACA, NEW YORK AREA IN 1949, 1950, AND 1951

Specimen No.	Sex	Total length, in mm.	Date
2 VN	♂	56	Apr. 20, 1949
		64.5	Nov. 10, 1949
38 HB	♀	24	July 6, 1949
		73	Apr. 22, 1951
60 HB	♂	51	Aug. 24, 1949
		74	Apr. 24, 1951
90 HB	♂	50.5	Aug. 30, 1949
		71	Mar. 30, 1951
104 HB	♂	49	Sept. 1, 1949
		65.5	Mar. 30, 1951
116 HB	♂	60.5	Sept. 5, 1949
		74.5	Mar. 30, 1951
51 HB	..	47	Aug. 23, 1949
		51	Sept. 5, 1949
		55	Sept. 26, 1949
87 HB	..	35	Aug. 30, 1949
		39.5	Sept. 17, 1949
88 HB	..	42.5	Aug. 30, 1949
		47	Sept. 17, 1949
105 HB	..	54	Sept. 4, 1949
		58.5	Sept. 17, 1949
86 SM	..	56	Sept. 4, 1949
		62	Oct. 13, 1949
87 SM	..	41	Sept. 4, 1949
		44.5	Sept. 16, 1949
47 VN	..	48	Sept. 6, 1949
		54.5	May 11, 1950
48 VN	..	38.5	Sept. 6, 1949
		41	Sept. 21, 1949
		41	Sept. 28, 1949
		41.5	Oct. 6, 1949
		45	June 7, 1950
57 VN	..	37.5	Sept. 8, 1949
		39	Sept. 24, 1949
		39.5	Oct. 13, 1949
59 VN	..	39.5	Sept. 8, 1949
		44.5	Oct. 6, 1949
66 VN	..	43	Sept. 21, 1949
		44.5	Oct. 20, 1949
140 HB	♂	51	Sept. 22, 1949
		52.5	Sept. 26, 1949
		55.5	Oct. 9, 1949
129 SM	..	59.9	Sept. 24, 1949
		62	Apr. 24, 1950
178 HB	..	54.5	June 20, 1950
		73.5	Sept. 4, 1950
118 VN	..	30	July 6, 1950
		41.5	Aug. 14, 1950
213 HB	♂	68	July 25, 1950
		71	Sept. 29, 1950
214 HB	♀	62.5	July 25, 1950
		71	Sept. 29, 1950
252 HB	..	28.5	Aug. 21, 1950
		33	Sept. 18, 1950
		33	Sept. 29, 1950
165 VN	..	41	Sept. 6, 1950
		42.5	Sept. 26, 1950
281 VN	..	40	Oct. 15, 1950
		39.5	Oct. 31, 1950

June or early July, at 31 or 32 mm. or larger, will often attain a length of 50 to 58 mm. before hibernation. The following May these frogs may grow 4 to 6 mm., 6 to 10 mm. in June, and the same in July. By this time individuals of both sexes are of mature size, the males about 60 mm., the females about 65 mm. in length. These may breed from late June to early August, approximately one year after transformation. From the beginning of August until mid-September, 8 to 12 mm. may be added to the length of these mature frogs. Males may attain a length of 70 mm. at the end of the growing season in the year following transformation; females may reach 75 to 80 mm. in the same length of time. The few records obtained, showing the full seasonal growth of frogs in their first season following transformation, indicate that males may gain as much as 22 mm., females up to 33.5 mm. (Table I—frogs 28 VN, 110 SM, 43 VN, 77 VN, 2 SM, 11 SM, 72 VN, 22 SM).

At the beginning of the season of growth, males ranging from 26 mm. to 65 or 70 mm., and females to 70 or 75 mm., may grow at about the same rate. The rate of growth of the male is, however, generally slower than that of the female. Both males and females show barely

perceptible yearly growth after lengths of 80 mm. are attained; growth in these large frogs appears to occur from mid-May to the end of June; throughout the remainder of the summer and fall there is often no detectable growth. Males of 90 mm. and females of 98 mm. presumably attain such size through the slow accumulation of a few millimeters in the early part of an unknown number of seasons. Flower (1925) reported that a greenfrog lived 10 years in captivity in the London Zoological Garden, but nothing is known about longevity under natural conditions.

Individuals that metamorphose in late summer (Table I—frogs 77 VN, 2 HW) reach adult size a year later. Although they probably do not breed that season, they certainly do the following year. Transformation size and date both play a role in determining when the individual will attain adulthood. Frogs that are small at transformation in late June (26 or 27 mm.) possibly do not become sexually mature until the next season during late summer after the breeding period.

Wright's (1920) estimate of the size of the greenfrog at yearly intervals was based on individuals of both sexes collected at random over a ten-year period. His calculations show much slower growth than the data from the present study indicate.

Growth of *Rana pipiens*

The propensity of this species to leave hibernation and spawning sites early in the spring and take to the surrounding meadows and fields reduces the possibilities of recapturing marked individuals. This is reflected by the 44 recaptures from 402 marked frogs. The maximum recorded distance traveled by a marked leopardfrog in this study was no more than 150 yards from the place where first captured. Recaptures indicated a wide variability of movement.

The species is generally abroad in late March or early April in this region and spawns soon after it appears. Wright (1914) found that under natural conditions the eggs hatch in from 13 to 20 days, and transformation occurs after 60 to 80 days of larval life. Transformation has occurred in the Ithaca area from June 30 to August 15; generally, however, most individuals transform during the first and second weeks of July. In the present study the earliest dates on which transformation was noted were July 5, 1949 and July 6, 1950. Size at transformation of 64 individuals collected in those years ranged from 20 to 30.5 mm. (average, 25 mm.); most were grouped between 23 and 26 mm. In 175 specimens Wright (*op. cit.*) found a range from 18 to 31 mm., with an average of 24 mm.

From the few complete individual seasonal growth records and the more numerous incomplete records a pattern of seasonal growth indicative of the species as a whole in this area may be pieced together. The data indicate that a few individuals reach adult size by the end of the season in which they transformed (Table II—frogs 51 HB, 140 HB, and 118 VN). Adult males range from 52 to 82 mm. in length; females, from 54 to 92.5 mm. From transformation early in July until hibernation in October, some frogs grow 22 mm. and perhaps more. Most frogs probably grow 8 or 9 mm. in July, if they transformed early, and the same in August (Table II—frogs 118 VN, 249 HB). Growth in September is more variable, ranging from about 2 to 6 mm., with about 5 mm. apparently not uncommon. In October there appears to be little or no growth. Most of the frogs that transformed during the first week in July probably had grown between 17 and 20 mm. by October.

A few individuals may breed in the year following transformation. All are probably of adult size after one full season of growth (Table II—frogs 38 HB, 60 HB, 90 HB, 104 HB, and 47 VN) and breed the following spring or 2 years from the egg stage, a year and 9 or 10 months after transformation.

Seasonal growth in sexually mature males that start the season at about the same size may vary from 8 to more than 20 mm. (Table II—frogs 2 VN, 60 HB, 90 HB, 116 HB). I have no records of the growth of leopardfrogs from May to June and only one from June to September. The data are not sufficient to indicate any differences in the rate of growth of males and females. Until sexual maturity is reached, growth is rapid during favorable months; following sexual maturity, as large size is approached, growth is much slower. Maximum size is probably approached two full seasons after transformation.

A leopardfrog lived in captivity 5 years 11 months (Flower, 1936). There is no information

TABLE III

GROWTH RECORDS OF 18 INDIVIDUALS OF *Rana catesbeiana* IN THE ITHACA, NEW YORK AREA IN 1949, 1950 AND 1951

Specimen No.	Sex	Total length, in mm.	Date
40 VN	..	54	Aug. 25, 1949
		89.5	June 16, 1950
42 VN	..	49	Sept. 2, 1949
		92.5	Apr. 22, 1951
58 VN	..	55	Sept. 6, 1949
		86.5	June 30, 1950
68 VN	..	59.5	Sept. 21, 1949
		61	Oct. 13, 1949
70 VN	..	52	Oct. 4, 1949
		53.5	Oct. 20, 1949
		54.5	May 11, 1950
73 VN	..	51	Oct. 6, 1949
		65	June 13, 1950
8 VN	..	58.5	Nov. 10, 1949
		70.5	June 16, 1950
86 VN	..	71	Apr. 18, 1950
		74	May 11, 1950
94 VN	..	60	May 11, 1950
		71.5	June 7, 1950
95 VN	♀	49.5	May 11, 1950
		73	July 11, 1950
		80	July 25, 1950
		87	Aug. 10, 1950
		92	Aug. 21, 1950
		101.5	Sept. 7, 1950
		103.5	Sept. 29, 1950
105 VN	..	63.5	June 13, 1950
		76	July 20, 1950
		98.5	Apr. 9, 1951
107 VN	♀	86	June 16, 1950
		122.5	Sept. 19, 1950
		122.5	Sept. 29, 1950
		122.5	Oct. 10, 1950
130 VN	♀	64	June 30, 1950
		80.5	Aug. 10, 1950
		89.5	Sept. 7, 1950
		92	Sept. 19, 1950
123 VN	..	67	July 11, 1950
		70	July 20, 1950
		78	Aug. 10, 1950
28 DP	..	57.5	Aug. 15, 1950
		68	Sept. 8, 1950
		72	Sept. 27, 1950
		74.5	Oct. 18, 1950
		75	Nov. 1, 1950
34 DP	..	47.5	Sept. 8, 1950
		48.5	Sept. 18, 1950
		49	Nov. 1, 1950
47 DP	..	47.5	Sept. 8, 1950
		49.5	Nov. 1, 1950
36 DP	..	47	Sept. 8, 1950
		48	Sept. 18, 1950
		48.5	Sept. 27, 1950
		48.5	Apr. 22, 1951

on the life span of this species under natural conditions.

GROWTH OF *Rana catesbeiana*

The bullfrog is usually the last species of frog in the Ithaca area to come out of hibernation and has been first recorded about May 15th over a period of years (Wright, 1914). A number of small individuals were collected on April 18, 1950 and on April 9, 1951. These early appearances were not due to unusually warm weather, for daily temperatures were even slightly below normal. Spawning usually occurs during the last week in June and early in July. The tadpoles are generally thought to spend two, sometimes three winters in the tadpole stage. They transform from early July to September and possibly to October. Length at transformation may vary from 36 to nearly 60 mm.; the average is about 52 mm. Prior to this study the latest autumnal records of the presence of bullfrogs in this area were September 22, 1900 and October 14, 1899 (Wright, 1914). In 1949 bullfrogs were collected as late as November 10th and small bullfrogs were common in one area on November 2, 1950. The mean temperatures for the months of September, October, and November 1949 and 1950 were within a few degrees of normal.

The immature bullfrog shows little growth until about the middle of May (Table III—frogs 70 VN, 86 VN). The lack of suitable food may limit the growth of small individuals during this period. The larger frogs could feed upon the smaller ones as well as crayfish, both common in the diet; yet before the middle of May only 3 or 4 mm. of growth is evident. The lack of

food does not appear to be entirely responsible for the slow rate of growth in larger frogs either at the beginning of the growing season or at its end. The same may be true for small individuals, although at these periods there is a paucity of suitable insect life on which they largely feed.

From the middle of May to the end of August the rate of growth is rapid. By the end of May it is possible for an individual to have grown nearly 10 mm. in length (Table III—frogs 94 VN, 73 VN). Eleven or 12 mm. are frequently added to the length in June, the same in July and August (Table III—frogs 95 VN, 105 VN, 130 VN, 123 VN). In September there are usually a few millimeters of growth (Table III—frogs 34 DP, 47 DP, 36 DP). However, it would be difficult to explain the large increment of growth of 40 VN, 58 VN, and 105 VN without assigning considerable growth in September. October and November may account for 1 or 2 mm. of growth (70 VN, 28 DP).

Seasonal increment in the bullfrog may reach 54 mm. without extreme acceleration of the growth rate at any time during the season, as exemplified by 95 VN. On the basis of the partial seasonal growth patterns of other individuals, the growth increment of this frog was only slightly more during certain periods of the season than that usually found. Other frogs, whose growth records show complete or nearly complete seasonal growth increment, are 107 VN, 130 VN, 105 VN and 42 VN. Seasonal growth in the first three may be estimated at about 50 mm. Most individuals in their first season after transformation probably grow between 40 and 50 mm. They are usually of adult size by the end of their first full season. Males attain adult size at approximately 85 mm., females at 90 mm., but breeding seldom occurs in individuals less than 100 mm. (Wright and Wright, 1949). Some might possibly breed late in the first full season following transformation.

Raney and Ingram (1941), who studied the growth rates of bullfrogs in Albany County, New York, found greater variation in the rate of growth of immature frogs than this study reveals. They recorded monthly increments during favorable months of from 3 to 18 mm. in immature frogs and yearly increases of 11 to 48 mm., which is less than that of the Ithaca population. These discrepancies are certainly in part reflections of habitat and seasonal differences.

Summary

Greenfrogs in the Ithaca, New York area are of adult size and may breed one year after transformation, if they metamorphose in late June at about 31 mm., or larger. Those that are of small size (26 to 28 mm.) at transformation in June, or those that transform somewhat later, are of adult size at the end of the following season and breed the next. Males appear to grow less rapidly than females, gaining as much as 22 mm. the first season after transformation while females may gain 33.5 mm. Growth in this species is slow in May; 3 to 5 mm. are gained from the middle to the end of this month. In June and July 6.5 to 10 mm. are added each month. In August growth is somewhat slower, and it levels off in September as the hibernation period is approached. Growth rates are roughly parallel in all sizes at the same period during the season, the males gaining less rapidly than the females, until males become about 70 to 75 mm. and the females about 75 to 80 mm. At this size seasonal growth is markedly reduced.

Leopardfrogs occasionally breed in the spring following the season in which they transformed. The majority are of mature size and breed two years from the egg stage. In most immature leopardfrogs the rate of growth during favorable months, June through August, is about 8 or 9 mm. each month; it is less in May and September. Leopardfrogs approach maximum size in two full seasons following transformation.

Most immature bullfrogs probably grow 40 to 50 mm. during their first season after transformation and are thus of adult size at the end of that period. Some may be sexually mature one year after transformation. Immature individuals may grow as much as 10 mm. by the end of May after leaving winter quarters. Eleven or 12 mm. are commonly added monthly from June through August. From September to hibernation in October or November a few millimeters in length may be added.

I am indebted to Dr. W. J. Hamilton, Jr. for the encouragement and guidance he has given

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The Generic Differentiation of the Swamp Treefrogs

M. B. Mittleman and J. C. List

THE swamp treefrogs of the United States and Canada are usually regarded as generically different from *Hyla* on the basis of such characters as the reduced size of the digital discs, the extent of the webbing of the toes, and the lineate or streaked dorsal pattern. But just as generally it is conceded that these are rather weak, if not artificial, criteria for this differentiation. In practice, identification of the species of *Pseudacris* depends more on familiarity with the *toute ensemble* of these little frogs then on the use of "key" characters which often fail miserably in application.

Comparison of various American species of *Hyla* possessing reduced webbing and small digital discs with members of the genus *Pseudacris* seems to indicate that *Pseudacris* is little more than a barely defined section or species complex of *Hyla*. Noble (1923) concluded that the alleged characters of *Pseudacris* were so nebulous that it was necessary to refer the species of this genus to *Hyla*. Harper (1939), in discussing *Pseudacris ocularis*, referred it to *Hyla*, but differed from Noble in considering *Pseudacris* as tenable for the other species of swamp treefrogs, while suggesting at the same time the possibility that *Hyla regilla* and *H. eximia* might properly be allocated to *Pseudacris*. The difficulty encountered in establishing satisfactory generic criteria for separating *Pseudacris* from *Hyla* is perhaps further evidenced by the fact that the species *H. regilla* and *H. wrightorum* were treated by Wright and Wright (1942: 92) in the section of their key to the Hylidae which is devoted to *Pseudacris* rather than to *Hyla*.

Even the most cursory examination of the overwhelming variety of species referred to the catch-all genus *Hyla* is sufficient to show that this genus is polyphyletic, and that several species groups warrant generic distinction. Smith and Taylor (1948) estimated that approximately 350 species are now assigned to *Hyla*, and the very magnitude of these numbers makes it desirable to maintain or establish such hyliform genera as will result in more natural and convenient groupings. Thus, the retention of *Pseudacris* is worthwhile if real and constant differences between this genus and *Hyla* can be found.

In order to elucidate the status and relationship of the swamp treefrogs, an exhaustive study of the external anatomy and of the bony morphology was made on a number of species of *Pseudacris* and *Hyla*. Skeletal structure was examined in specimens cleared and stained with Alizarin Red S, using a technique modified after that of Davis and Gore (1936). Forms thus studied include the following:

Hyla crucifer crucifer Wied
Hyla eximia Baird
Hyla lafrentzi Mertens & Wolterstorff
Hyla miotympanum Cope
Hyla picta (Gunther)
Hyla regilla Baird & Girard
Hyla rickardsi Taylor
Hyla smithi Boulenger
Hyla squirella Latreille
Hyla staufferi Cope
Hyla underwoodi Boulenger
Hyla versicolor versicolor LeConte
Hyla wrightorum Taylor

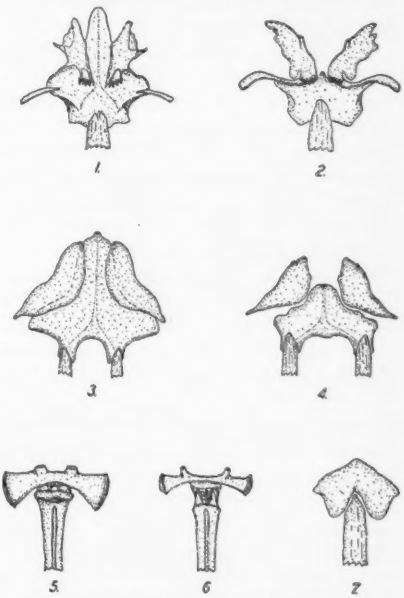
Smilisca baudini baudini (Duméril & Bibron)

Pseudacris brachyphona (Cope)
Pseudacris clarki (Baird)
Pseudacris nigrita feriarum (Baird)
Pseudacris nigrita nigrita (LeConte)
Pseudacris nigrita triseriata (Wied)
Pseudacris ocularis (Holbrook)
Pseudacris ornata (Holbrook)

No consistent differences could be found externally between *Pseudacris* and the species of *Hyla* studied by us. Nor is it possible to differentiate between these genera in the details of the vertebral column, the pectoral girdle, or the limbs. However, study of the cranial osteology reveals certain important and constant differences between *Pseudacris* and *Hyla*.

In *Pseudacris* the anterior bony palate consists of a large and expanded sphenethmoid which almost meets the premaxillae, and which bears upon it the dentigerous vomers. The sphenethmoid is longer than the vomers and is at least coextensive with them for their entire length; the latter are rather small and do not usually make contact with the palatines. (Fig. 1.) Dorsally, the sphenethmoid is also elongate, and is at least coextensive with the length of the nasals, or else extends well beyond them anteriorly. The nasals are long and broad, and anteriorly at least incline toward each other and sometimes meet. The frontals are slender, and usually form a suture with the exoccipitals and the prootics, but rarely suture between themselves at their posterior ends. The frontal fontanelle is large, extending from the sphenethmoid to the exoccipitals, and lacks any secondary centers of ossification or other artifacts (Fig. 3).

In the species of *Hyla* we have studied, the anterior bony palate is constituted almost entirely of the relatively large vomers; the sphenethmoid is considerably reduced and sends forth only a short process which barely or not



Figs. 1–7. Skeletal elements of *Pseudacris nigrita triseriata*, male, from 5 miles south of Salisbury, Wicomico County, Maryland; *Hyla crucifer crucifer*, male, from the same locality; *Limnaoedus ocularis*, male, from Bradford County, Florida. Anterior palatal region: Fig. 1, *Pseudacris;* Fig. 2, *Hyla;* Fig. 7, *Limnaoedus*. Anterior cranial region: Fig. 3, *Pseudacris;* Fig. 4, *Hyla*. Dorsal sacral region: Fig. 5, *Pseudacris;* Fig. 6, *Limnaoedus*.

at all extends between the vomers. The palatines are usually robust and either form a tripartite suture with the vomers and the sphenethmoid or else are barely separated from the vomers. (Fig. 2.) The reduction of the sphenethmoid is also evident dorsally, where it barely extends anteriorly between the well-separated, foreshortened nasals (Fig. 4). The nasals often produce elongate alary processes which are superimposed on the palatines for half or more the length of these latter bones.

The frontals are quite stout in *Hyla*, and appear to be shorter than in *Pseudacris*, forming a suture with the prootics but not the exoccipitals. The frontal fontanelle in *Hyla* is much smaller than in *Pseudacris*, partly because of the stouter frontals and partly due to the presence of a thin mass of calcareous matter. The frontals often form a suture between themselves at their posterior ends, or else are joined together with the exoccipitals by a mass of what appears to be secondary ossification.

The foregoing differences are found consistently in the species of *Hyla* and *Pseudacris* that we have investigated. Species such as *Hyla regilla*, *H. wrightorum*, and *H. eximia*, whose affinities with *Pseudacris* have been suggested, were found indistinguishable from other species of *Hyla* but well differentiated from *Pseudacris*. No osteological differences were found between *Smilisca* and *Hyla*.

Perhaps most interestingly, neither of the foregoing descriptions of what are believed to be fundamental generic characters was found to be applicable to *Pseudacris ocularis*. The generic status of this diminutive frog has been the subject of considerable debate almost from the time of its description by Holbrook (1838), who referred it to *Hylodes*. Shortly thereafter LeConte (1855) considered *ocularis* a species of *Hyla*, in which he was followed by Noble (1923) and Harper (1939), while Wright (1932) pointed out a number of discrepancies of structure and habit between *ocularis* and other species of swamp treefrogs, but concluded that it was best allocated to *Pseudacris*.

The differences between *ocularis* and other species of *Pseudacris*, as reported by various authors, may be summarized as follows: (1) vomers lacking teeth (odontoids) (dentigerous in all other forms of *Pseudacris*); (2) hind limb proportionately longer than in all other forms; (3) size very small, maximum adult length only equal to or less than transformation size in all others; (4) vocal sac not extending to the tip of the lower jaw as it does in the other species; (5) dorsal pattern usually non-lineate; (6) eggs laid singly (in a mass in all others); (7) spiracle of the tadpole closer to the vent than to the snout (closer to the snout in the others); and (8) habitat herbicolous or arboreal, vocalizing not performed in water (other species of *Pseudacris* are terrestrial and apparently vocalize only when at least partially submerged).

The significance and/or consistency of certain of these differences between *ocularis* and its supposed congeners may be subject to varying interpretations. For example, the presence or absence of vomerine teeth (odontoids) in salientian forms has been regarded by some workers as only of the most trivial importance, of little or no use in separating species, much less genera (Noble, 1923, and 1931). On the other hand, where the variation in these appurtenances has been carefully investigated and their subjective importance properly evaluated, their presence or absence provides a useful and valid specific or generic character (cf. Parker, 1934). In the present instance there can be no doubt of the consistency with which *ocularis* has edentulous vomers, or of the equal consistency with which vomerine odontoids are present in all other *Pseudacris*. Taken in conjunction with the other differences previously enumerated, as well as those appended below, the edentulate vomers of *ocularis* seem indicative of an inherent difference of phylogeny between this species and other swamp treefrogs.

A detailed comparison of the bony structure of *ocularis* and other species of *Pseudacris* reveals a number of points of difference:

(1) *Sphenethmoid*. In *ocularis* the two lateral elements of this bone do not attain complete fusion dorsally, and while they closely approximate each other, they are more properly described as paired rather than fused. Ventrally the lateral elements are sometimes wholly separated on the midline, and even when more or less completely fused they leave a prominent posterior notch (Fig. 7). In other forms of *Pseudacris* the sphenethmoid is a robust structure, the lateral elements forming a complete suture dorsally and ventrally, thereby comprising a complete capsular girdle for the anterior cranium (Fig. 1).

(2) *Parasphenoid*. This bone in *ocularis* (Fig. 7) does not fuse with the sphenethmoid, nor does it lie partially superimposed on the latter bone as it does in all the others (Fig. 1). Instead, it fits into the posterior notch of the sphenethmoid which has been previously described, and is cartilaginously joined with the sphenethmoid, rather than calcareously.

(3) *Mentomeckelian*. These bones are elongate and slightly hook-shaped in *ocularis*, so that they form an inverted V in their commissure. In other species of *Pseudacris* the mento-

meckelians are short straight bars which form a line making an obtuse angle with the dentaries, as compared with the relatively acute angulation in *ocularis*.

(4) *Hyoid*. The corpus of the hyoid is non-calcified in *ocularis*, and almost invariably heavily calcified in other forms of *Pseudacris*.

(5) *Sternum*. A small amount of calcification is seen only in the mesosternum in *ocularis*, and is wholly lacking in the xiphisternum and omosternum. In other species of *Pseudacris* all three sternal elements are rather heavily calcified, except for the extreme tip of the xiphisternum.

(6) *Pelvic girdle*. The sacral diapophyses are much narrower in *ocularis* (Fig. 6) than in the other forms (Fig. 5). In addition, in *ocularis* the dorsal ridge of the urostyle abruptly bevels forward and downward toward the articular surfaces, forming an elongate dorsal fontanelle which extends posteriorly beyond the arc subtended by the sacral diapophyses. In the other species of *Pseudacris* the dorsal fontanelle of the urostyle is very small or absent, and when present is well within the subtended arc of the sacral diapophyses.

The various skeletal differences enumerated here, as well as the other characteristics of structure, pattern, breeding, and habits which we have discussed previously, suggest in their totality a fairly primitive hylid representing today either the progenitive form which gave rise more or less directly to *Pseudacris*, or else an offshoot of that stock. In sum, the species *ocularis* appears to be at least as far removed from the species of *Pseudacris* as these latter species are from *Hyla*. Accordingly, we propose that for *ocularis* a separate genus be erected, for which we suggest

***Limnaoedus*, gen. nov.**

GENOTYPE.—*Hylodes ocularis* Holbrook, 1838.

DIAGNOSIS.—A hylid genus most nearly related to *Pseudacris*, and differing from it as follows: vomers edentulous; parasphenoid fitting in a posterior notch of the sphenethmoid; the sphenethmoid incompletely fused dorsally; mentomeckelians form an inverted V at their commissure; omosternum and xiphisternum non-calcified; corpus of the hyoid non-calcified; sacral diapophyses slender; an elongate dorsal fontanelle present at the articular end of the urostyle, the fontanelle extending posteriorly beyond the sacral diapophyses; size small, maximum length approximately 19 mm.; eggs laid singly; pattern usually non-lineate; habitat herbicolous or arboreal.

INCLUDED SPECIES.—*Limnaoedus ocularis* (Holbrook).

The name *Limnaoedus* is derived from the Greek λίμνη (marsh) + ἀοιδός (singer).

We wish to express our sincere appreciation to Dr. Hobart M. Smith for his kind interest and many helpful suggestions which have materially benefitted this study.

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The Amphibians of Big Black Mountain, Harlan County, Kentucky

ROGER W. BARBOUR

BETWEEN 1939 and 1948, the writer camped over four months on Big Black Mountain in Harlan County, Kentucky, making a survey of the amphibians, reptiles, and mammals of the region. Previously published reports deal with the reptiles (Barbour, 1950a) and the mammals (Barbour, 1951). For a general discussion of the area, reference is made to these papers.

Big Black Mountain reaches a maximum elevation of 4150 feet above sea level, and is the highest point in Kentucky. It lies largely in Harlan County, Kentucky, but occupies a part of adjacent Wise County, Virginia. The majority of the collections discussed in this paper were made within a four-mile radius of the summit of the mountain, centering at the point designated "Grassy Gap" (United States Geological Survey, Estillville Sheet). Collections made at other points are so indicated.

In the following annotated list of species of amphibians known to occur on the mountain, average measurements are given first, followed by extremes (in parentheses). Body length is the distance from the tip of the snout to the posterior end of vent; tail length is the distance from the posterior end of the vent to the tip of the tail. All specimens are in the zoological collections of the University of Kentucky.

The present paper is a portion of a thesis submitted to the graduate school of Cornell University, Ithaca, New York. The writer is indebted to Dr. William J. Hamilton, Jr., for advice, suggestions, and criticisms.

ANNOTATED LIST OF SPECIES

Triturus viridescens viridescens (Rafinesque).—A single red eft was taken August 10, 1948, at an elevation of 2200 feet, as it crawled across a path.

Ambystoma maculatum (Shaw).—An individual was taken February 12, 1948, from the basement of a residence in Lynch. I have seen no other species of *Ambystoma* from the Black Mountain area.

Desmognathus fuscus welleri Barbour.—A series of 761 individuals of this recently described subspecies (Barbour, 1950b) was taken from the Black Mountain area. This is apparently by far the commonest amphibian of the area; specimens were taken from the lowest valleys to the very summit of the mountain. No individuals were taken far from water, but almost every wet spot supported a population. Springs, spring runs, roadside puddles, and streams were abundantly populated.

Forty-five egg-bearing females, taken between June 5 and August 28, 1948, were examined. The egg number per female varied from 5 to 39, with an average of 27. The largest ovarian eggs were 4.5 mm. in diameter. No correlation between date and egg size was evident; apparently egg laying continues throughout the summer.

On June 14, 1948, a cluster of 16 eggs averaging 4 mm. in diameter was found under a stone at the edge of a small stream at an elevation of 3000 feet. On August 12, 1939, a group of 14 larvae averaging 20 mm. in total length and an attendant female were found at an elevation of about 2000 feet on Pine Mountain in the vicinity of Rosspoint. The adult and young were in the hollow of a rotten limb at the edge of a small stream.

This salamander is known by nearly all residents of the area, due no doubt to its abundance; it is generally referred to as a "spring lizard."

Desmognathus ochrophaeus ochrophaeus Cope.—Of 111 individuals collected, 104 are typical *ochrophaeus*, while 7 show a dorsal color pattern approaching that of *carolinensis*.

Measurements of the five largest males are as follows: body length, 43.2 (41–45) mm.; tail, 45.2 (42–50). Sixteen egg-bearing females have a body length of 35.9 (31–41) mm.; tail, 37.3 (31–43).

This species is apparently restricted to woodlands and woodland edges on Black Mountain where it has been taken at elevations ranging from 2200 to 4150 feet. Numerous specimens were found under the bark of fallen trees in company with *Aneides*; unlike *Aneides*, this salamander was frequently taken under stones and logs on the forest floor.

Seventeen females bearing ovarian eggs were

taken between May 4 and August 23. The largest eggs were 3 mm. in diameter. No correlation between egg size and time of year was evident. The number of eggs per female varied from 10 to 15, the average being 12.4.

On rainy nights throughout the summer of 1948, individuals could be found in the logging roads about the summit of the mountain. On the night of July 14, 1948, a male and female were found together on a miniature flood plain in a dirt road. The male was grasping the right side of the lower jaw of the female, and their bodies were straight, forming about a 30 degree angle. This position was held for a half minute. When the male released the female, both animals scurried out of the light of my lantern. Tracks in the mud revealed that considerable writhing and turning had taken place prior to my arrival.

Desmognathus monticola Dunn.—Specimens were taken at four localities, at elevations ranging from 1800 to 4000 feet. Seven individuals were taken from a mucky spring in Lynch (1800 feet elevation); one was found in a muddy roadside ditch at an elevation of 4000 feet; another was taken under a stone in a muddy area in an abandoned road at an elevation of 2500 feet; 25 were collected from a muddy spring run at an elevation of 2200 feet.

Measurements of the five largest males are as follows: body length, 58.2 (51–62) mm.; tail length, 60 (54–69). The five largest females have a body length of 55.2 (49–62) mm.; tail length, 53 (44–60). The five smallest specimens taken have a body length of 18.2 (17–19) mm.; tail length, 16.2 (13–18).

It appears that in the Black Mountain area, *D. monticola* is restricted to muddy habitats such as springs and spring runs. However, numerous such areas yielded only *fuscus*; never were *monticola* and *fuscus* found together.

In 1948, three egg-bearing females were taken. Two were found on July 10 at an elevation of 1800 feet; the larger (body length 62 mm., tail 53) contained 41 eggs, the smaller (body length 57, tail 44) contained 40. The eggs in each complement had an average diameter of 2 mm. The third (body length 53, tail 57) was collected on July 14 at an elevation of 2200 feet; it contained 18 eggs, with an average diameter of 1.25 mm.

Plethodon glutinosus glutinosus (Green).—Bishop (1943), Grobman (1944), and others have pointed out the complex situation regarding *Plethodon glutinosus*. Fifty-one specimens of *Plethodon* from the Black Mountain area are referred to this form. In general, they have the characters ascribed to *glutinosus*; in particular, there are numerous variants as follows: (a) five of the specimens have 15 costal grooves, forty-five have 16 and one has 17; (b) nine specimens have no spots, 21 have spots on both the dorsum and sides, 21 have unspotted backs and spotted sides; (c) of the 42 specimens with spotted sides, 41 have them arranged in the form of a band between the insertion of the fore limbs and hind limbs, and one individual has the lateral spots scattered promiscuously over the sides; (d) in seven specimens the throats are as dark as the bellies, 44 have throats conspicuously lighter than the bellies, with some definitely approaching the characters of *P. g. albagula* as given by Grobman (1944).

The five largest males have a body length of 71 (67–75) mm.; tail, 68.1 (66–73). The body length of the five largest females is 58.6 (56–65) mm.; tail, 65.2 (62–74).

At elevations ranging from 2750 to 4100 feet, specimens were taken beneath logs, stones, and boards along the logging roads, but appeared to be more abundant under logs, stones, and pieces of bark on the forest floor of woodland areas. Usually, at least one slimy salamander could be found under the bark scattered about the naked bole of a dead chestnut tree. On several occasions, individuals were taken in company with *Aneides* under the loose bark of dead logs.

An egg-bearing female, taken on July 9, contained 13 ovarian eggs, averaging 0.5 mm. in diameter; another found on August 5, contained 16 eggs, with an average diameter of 1 mm.

Plethodon richmondi Netting and Mittleman.—Seven of the nine specimens collected agree with *richmondi* in number of costal grooves, ventral coloration, and in the presence of gold flecks on the dorsum. Two of the specimens have only 19 costal grooves, but agree with *richmondi* in all other characters. The number of costal grooves varies from 19 to 21, with 20 the commonest number (five specimens). Two individuals have 21 grooves; two have 19.

Four males have a body length of 40.5 (34–50) mm., and a tail length of 34.3 (26–39). In four females the body length is 41.2 (34–50) mm.; tail length, 40.5 (34–49).

All specimens were taken beneath logs and stones in wooded areas at elevations ranging from 3000 to 4000 feet. Individuals were found in situations varying from a virgin stand of timber to dry, second growth oak-hickory thickets.

Adult females collected June 15 to July 15, 1948, showed no signs of ovarian activity.

Aneides aeneus (Cope).—The ten largest males have a body length of 55.9 (49–63) mm., and a tail length of 61.7 (47–68). Nine egg-bearing females have a body length of 60 (54–69) mm.; tail length, 59.1 (38–72) (Table I). Measurements of the ten smallest individuals (collected June, July, and August) are as follows: body length, 23.9 (19–27) mm.; tail, 19.3 (13–24).

TABLE I

DATA CONCERNING NINE EGG-BEARING SPECIMENS OF *Aneides* COLLECTED ON BLACK MOUNTAIN IN 1948

Elevation in feet, other measurements in millimeters

Date	Elevation	Body length	Tail length	Number of eggs	Average egg size
June 8	4100	64	72	33	1.0
June 8	4150	66	62	40	1.5
July 4	3900	62	62	18	1.0
July 9	3800	59	47	33	1.5
July 9	3700	55	58	19	1.25
July 9	3900	54	38	17	1.75
July 9	3900	57	54	25	1.5
July 22	4050	69	66	29	0.75
Aug. 9	4000	54	65	28	2.0

This species was found at elevations ranging from 2300 to 4150 feet. In 1939, *Aneides* was common underneath the loosely adhering bark of dead chestnut trees. In 1948, the chestnut boles were bare; the salamanders were living largely under the bark of tree top remnants left as a result of logging operations. One specimen was taken from a crevice in a sandstone cliff; another was found in a cavity of a standing dead chestnut, some 14 feet from the ground. All other specimens (46) were taken beneath the bark of tree tops mentioned above.

Ten young with a total length of 50 mm. or less were taken. Their distribution in time is as follows: two, taken June 23 are 35 (34–36) mm. in total length; one, collected July 9, is 46 mm.; seven, collected August 9, average 45.3 (35–50) mm.

A cluster of 32 eggs, averaging 4.5 mm. in diameter, was found July 4, 1948, under the bark of a fallen tree at an elevation of 3500 feet, in Nim Hollow. The eggs were attended by an adult which escaped.

Gyrinophilus porphyriticus duryi (Weller).—Three adults were taken; all are referred to *duryi* on the basis of the dorsal spotting. One specimen shows some of the overall cloudiness attributed to *porphyriticus*; another shows chin markings reminiscent of *danielsi*.

Measurements of an adult male are body length, 80 mm.; tail, 50. Two females have a body length of 78.5 (68–89) mm.; tail, 48.5 (32–65).

Two specimens were taken at an elevation of 3750 feet under stones along a logging road. Although the area was damp, there was no standing water nearer than 25 yards. The third specimen was found under a stone in a small stream in a virgin stand of timber at an elevation of 3500 feet.

Five larvae were taken on July 4, 1948, from under stones in a small stream at an elevation of 3500 feet. The five individuals have a body length of 51.8 (50–53) mm.; tail (three specimens), 30 (25–36).

Pseudotriton montanus diastictus Bishop.—Two specimens were taken, both of which exhibit the clearness of ground color, the immaculate venter, and the distribution of pigment typical of *diastictus*. Measurements of the two individuals, both females, are body 52 (48–56) mm.; tail, 33.5 (33–34).

One of the specimens was found July 19, 1948, in a pile of wet leaves and mud at the edge of Looney Creek in Lynch (elevation 1800 feet). The second specimen was taken August 18, 1948, underneath a stone in a dry, rocky pasture at an elevation of 2200 feet. Other vertebrates taken in this latter habitat were largely *Carphophis* and *Bufo*.

Eurycea bislineata bislineata (Green).—Seven specimens were collected; all agree with *cirrigera* in costal groove counts and the character of the dorsolateral stripes; none, however, has the pronounced cirri. The specimens are assigned to *bislineata*, but the Black Mountain population apparently represents an intergrading group. The two largest specimens have a body length of 41.5 (40–43) mm.; tail, 44.5 (43–46). The measurements of the two smallest are body 20.5 (20–21) mm.; tail, 14 (10–18).

Taken at elevations ranging from 2200 to 2600 feet, specimens were found only along watercourses. Some were taken by day under stones in the streams; two individuals were secured by night as they crawled over the stones projecting above the water from the bed of Looney Creek.

One of the striking features of the fauna of the Black Mountain area is the apparent scarcity of *E. bislineata*; overturning hundreds of stones in what appeared to be suitable habitats revealed only the few individuals mentioned. In some sections of eastern Kentucky, notably around Morehead, Rowan County, a hundred specimens can be secured easily in an afternoon's collecting.

Eurycea longicauda longicauda (Green).—The three specimens collected are all clearly referable to this northern race; there is no evidence of intergradation with *guttolineata*.

Body and tail measurements of an adult male are 54 and 60 mm.; of an adult female, 60 and 90; a second male with a partially rejuvenated tail has a 57 mm. body. The two males have well-developed cirri; those of the female are short and blunt. Two specimens were taken June 14, 1948, at an elevation of 2250 feet on a north-facing slope; the third was taken June 23, on a south slope at an elevation of 3750 feet. All were beneath stones along little-used roads. None was found in habitats that could be called wet; two were in an area that was dry and sunny.

Bufo terrestris americanus Holbrook.—Sixty-four specimens are referred to this form, on the basis of number of warts per color spot, wart size, ventral spotting, and condition of the infraorbital crest and paratoids. No single character is sufficient to separate the species of *Bufo* on the mountain; a complete series leading from *B. t. americanus* to *B. w. fowleri* can be assembled from the specimens at hand on the basis of any one of the above characters. By using the four characters mentioned above, the bufos of Black Mountain can be quite readily separated.

Snout-vent length of five egg-bearing females is 91.4 (82–104) mm.; of five males showing secondary sexual characters, 77.4 (73–86).

In addition to the usual characters distinguishing the sexes, it was noted that the female has a slightly smaller tympanum. In six males, the rictal width averages 4.51 times the tympanum height; in six egg-bearing females, 5.32 times. A similar divergence holds in the number of times the tympanum height goes into the rictus-snout distance.

This form was found at elevations ranging from 1530 to 4150 feet. Concerning the vertical distribution of this species, 79 percent came from elevations greater than 3500 feet; 6.25 percent from between 3000 and 3500 feet; the remainder, from below 3000 feet. Toads were taken in various situations, ranging from dry, open areas to dense mesophytic woodland. They were quite common along roads.

Adult females with ovarian eggs were taken from June 13 to August 13. Males were heard calling from temporary puddles in and along the roads from June 5 to August 20. Occasionally a dry period as long as two weeks would lapse without a single toad being heard; a rain would bring them to the puddles again.

TABLE II

STOMACH CONTENTS OF 12 SPECIMENS OF *Bufo t. americanus* COLLECTED IN JUNE AND JULY ON BLACK MOUNTAIN

Food item	Volume (%)	Frequency (%)
Beetles	70.0	100.0
Millipedes	16.25	41.5
Snails	10.4	24.9
Spiders	2.5	16.6
Diptera	0.85	8.3

A single active toad was encountered during midday. This was a large female hopping over the forest floor in a stand of virgin beech-birch-maple. During midday, the majority of the toads sought shelter. At this time fruitful collecting resulted from turning over stones, logs, and boards along the logging roads about the summit of the mountain. During the late afternoon the toads became more active, emerging from hiding and hopping about. Numerous individuals were observed at night along the roads, and almost any muddy or dusty area revealed their sprawling tracks.

The examination of 12 stomachs revealed that beetles formed the major part of the diet in June and July (Table II).

Ten of the stomachs were taken from toads collected along a logging road at an elevation of 4000 feet on the night of July 14, 1948. It

was observed that on this night beetles were the commonest invertebrates evident along the road, followed by millipedes, snails, and spiders, in that order. This is precisely the order of their percentage, by bulk and by frequency, in the above stomachs. Apparently, availability was the determining factor in food selection in this instance.

Bufo woodhousei fowleri (Hinckley).—One hundred and thirty-five toads that are referred to this species were collected; characters used to separate this and *B. t. americanus* are given under the latter. Nine individuals thought to be intermediate between this and *B. t. americanus* were collected. The snout–vent length of seven males is 62.3 (56–76) mm.; of four females, 73.3 (68–79) mm.

TABLE III

STOMACH CONTENTS OF 12 SPECIMENS OF *Bufo woodhousei fowleri* COLLECTED IN JUNE AND JULY ON BLACK MOUNTAIN

Food item	Volume (%)	Frequency (%)
Beetles	67.43	91.7
Millipedes	14.46	24.9
Ants	13.75	41.5
Orthoptera	2.60	16.6
Asellus	1.66	8.3

This form was taken at elevations ranging from 1300 to 4100 feet. Of the total collected, 5.18 percent were from above 3000 feet; the remainder were taken at elevations ranging down to 1300 feet. Individuals were found in a variety of situations, although largely along streams at night and under cover of stones and logs by day.

Above 3000 feet, seven typical *B. w. fowleri*, seven hybrids, and 55 typical *B. t. americanus* were taken. At elevations below 3000 feet, 128 typical *w. fowleri*, two hyrbids, and eight typical *t. americanus* were taken. Random collecting below 3000 feet indicated a higher proportion of *w. fowleri* to *t. americanus* (16:1) than the reciprocal above 3000 feet (79:1).

Egg-bearing females were collected from June 12 to July 15. Males were observed calling on July 14 and 15. A series of newly transformed toads was collected from the banks of Looney Creek in Lynch on the night of July 16.

Stomachs of twelve typical *w. fowleri* were examined. Beetles formed the bulk of the food eaten (Table III).

Pseudacris brachyphona (Cope).—All collected from the Black Mountain area are clearly referable to this species.

A series of 76 individuals collected during June and July, 1948, shows a very one-sided sex ratio: 62 males to 14 females. The snout–vent distance of 62 males is 30 (27–33) mm.; of 14 females, 34.8 (31–37).

Wright and Wright (1942) give the size of males as 26–30 mm., females as 27–34. Their measurements are from the snout to the rear end of the body back of the vent. The snout–vent distance is slightly less than the Wrights' measurement; even so, both sexes of the Black Mountain specimens average larger than the sizes given by those authors.

TABLE IV

STOMACH CONTENTS OF 10 SPECIMENS OF *Rana clamitans*, COLLECTED FROM JUNE TO AUGUST, 1948, ON BLACK MOUNTAIN

Food item	Volume (%)	Frequency (%)
Coleoptera	22	50
Lepidoptera (adult)	18	20
Lepidoptera (larvae)	15	20
Cambarus	15	20
Millipedes	10	20
Orthoptera	13	20
Hemiptera	7	10

Individuals were found at elevations ranging from 2200 to 4000 feet. With a single exception, all specimens were taken at night from springs or roadside puddles. A male was found in the early afternoon on the leaf mold of a thicket at 2200 feet elevation. The nearest standing water was some 25 yards distant.

Egg-bearing females were taken between June 23 and August 14. Males were heard calling from puddles from June 10 to August 18. One individual was heard calling in the later afternoon from the forest floor about 200 yards from any standing water.

Fresh eggs were found on July 14, 15, and 20, 1948. Mated pairs were taken on June 14 and 15.

Hyla crucifer crucifer Wied.—A single specimen was collected from a low tree branch at an elevation of 4000 feet. Individuals were oc-

casionally heard calling about the summit of the mountain.

Hyla versicolor versicolor (Le Conte).—All specimens of *Hyla versicolor* collected in the Black Mountain area are referred to this subspecies. The snout–vent length of 23 males is 44.3 (39–50) mm.; of four females, 54.7 (52–57).

All were found at elevations ranging from 1300 to 4050 feet. An adult male was collected from a leaf in a brier patch; all others (28) were from ponds, puddles, or along watercourses.

Egg-bearing females were taken from June 24 to July 19, 1948. Individuals in amplexus, and freshly laid eggs were observed on July 15 and 19; one metamorphosing individual was taken on each of these dates from the banks of a quiet pool in Looney Creek.

On the rainy night of July 15, 1948, treefrogs were abundant along Looney Creek in Lynch. Individuals were calling from the shrubbery along the stream and were numerous on the bare rock of the stream bed. Those in the stream bed were very conspicuous in the light of a gasoline lantern. Three pairs were found in amplexus.

About the summit of the mountain, puddles in and alongside the roads were utilized as breeding areas; at lower elevations, eggs were deposited in quiet pools in the streams and in farm ponds.

Rana catesbeiana Shaw.—Two subadult females were collected July 15, 1948, from the Poor Fork of the Cumberland River a few miles below Cumberland. One was caught at the edge of the stream; the other at the edge of a small farm pond about 25 yards distant. The familiar call of the bullfrog was heard only on the above mentioned stream below Cumberland. None were heard or seen in Looney Creek.

The two specimens are 69 (66–72) mm. in snout–vent length. Both are mottled beneath and dark above. Dorsally there are a few minute, round, black spots.

Apparently, this form is replaced at the higher elevations by the greenfrog. Natives report the bullfrog as absent in the smaller streams, but common in the lower reaches of the Poor Fork of the Cumberland River.

Rana clamitans Latreille.—The four largest females (all bearing eggs) collected are 93 (86–97) mm. in snout–vent length. The four largest males 86.7 (78–91).

This species was taken at elevations ranging from 1300 to 4050 feet, but only along watercourses, ponds, and springs. Nearly every pool in the mountain streams at the higher elevations supported one or more individuals. Every spring examined about the summit of the mountain harbored one to three frogs.

Females containing eggs were taken from June 6 to July 15. Two transforming tadpoles were collected on August 25 from the bank of a pool at an elevation of 1850 feet in Wise County, Virginia. Snout–vent and tail length of these individuals are 26–30 and 24–34 mm., respectively. In each, the hind legs are well developed; the animals were able to hop.

A pair of adults in amplexus was found in the bed of Looney Creek on the night of July 15, 1948. They were startled on a gravel bar some 5 feet from the edge of the stream; their second leap carried them into the water where, still in amplexus, they hid under some trash. When collected, the female exuded some ripe eggs.

Of the food items found in the stomachs of ten adults, beetles were most prominent both in quantity and frequency (Table IV).

Rana sylvatica sylvatica Le Conte.—Known from a male collected August 9, 1939, from an oak-chestnut thicket at an elevation of 3900 feet. The individual was encountered at midday.

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Eggs, Egg-laying and Incubation of the Snake *Elaphe emoryi* (Baird and Girard)

HUGH CLARK

TWO females of *Elaphe emoryi* were collected at Manhattan, Kansas on May 18. Specimen No. E-2 weighed 213 g. and was 975 mm. in length; E-3 weighed 190 g. and was 945 mm. in length. Neither snake ate voluntarily, though both were force fed small rats at intervals of about three weeks. An adult male collected at the same time ate readily in captivity.

E-2 deposited five eggs on July 4; E-3 laid four eggs on July 8. Of the latter clutch the first was laid shortly after noon and the last at 5:20 PM. Prior to laying each egg, there were twitching movements of the body and rapid breathing and extrusion of the tongue; but the process was completed without movement of the body itself, apparently accomplished by uterine or cloacal contractions. At 5:21 PM the tail was raised from the last egg and was so maintained for 9 minutes (the position of the snake was noted by diagram); at 7:45 she was in precisely the same position. Both E-2 and E-3 shed their skins on July 10.

EGGS

Since no recorded description of the eggs of *E. emoryi* has been found, the following one is included. The eggs of E-2 were white, leathery-firm and unblemished. Those of E-3, also white, bore calcareous crystalline deposits on the surface; between the limy spots the shell had much the same texture as that of E-2 eggs, though it was translucent, allowing the yolk to show through and giving thereby a mottled appearance. In shape the eggs were truncate cylinders, though the diameter was slightly greater at the middle of the long axis, thus approaching an ellipsoidal form in longitudinal section. Measurements of length, width, volume, weight and density were taken as follows: length and width were measured with a caliper, with estimations to the nearest 0.1 mm.; volume was measured by displacement of water in a 100-c.c. graduate; weights were determined on an analytical balance to the nearest 0.01 g. (Table I).

It is apparent that the eggs of the smaller clutch are greater in weight, volume and length though their diameters are approximately the same. It is also observed that the total weight of the smaller clutch is 31.6 percent of the mother's weight, whereas the combined weight of the E-2 eggs is 33.4 percent. Variation of length and volume and constancy of width suggest that the diameter of the egg is limited, presumably by the distensibility of the oviduct.

INCUBATION

The eggs of E-2 were placed on a screen wire platform at the bottom of a four-gallon glass container, provided with cover. The bottom of the jar was covered with water in order to provide an atmosphere of 100 percent relative humidity. This proved to be inadequate, for the eggs became shrunken and lost an average of 1.0 c.c. in volume by July 8 (three days). Hence, when the eggs of E-3 were added to the container on July 8, a coarse, clean cloth was placed over the wire platform and its ends were allowed to dip into the water. Strips of muslin were also laid above the eggs, serving as wicks to bring water in contact with the shell. Care was observed to cover not more than half the surface of the egg by the moist cloths. Air in the container was flushed daily to prevent accumulation of carbon dioxide. Following this treatment for one day the lost volume of the eggs was recovered.

The eggs of E-2 suffered a loss of weight of 1 g. in the first three days which, on the basis of the analysis of Galimard (1904) and Sommer and Wetzel (1904), represents about 15 percent of the water content of the egg. Following the curve of these eggs after the wick was applied (third day), it is apparent that they not only recovered the loss but, moreover, increased weight approximately 15 percent beyond the corresponding weights of E-3 eggs (Fig. 1).

Since E-3 eggs were transferred almost directly from the uterus to the incubation chamber, in contact with water, their increase must represent the normal water uptake in the course of embryonic anabolic changes. The desiccated eggs of E-2 then absorbed water in excess of

the needs of the embryo. Implicit in this observation is the fact that by virtue of partial desiccation the yolk adsorbed additional water. This may be viewed as a device whereby the embryo is assured of a sufficient water supply in spite of unfavorable conditions, such as prolonged drought, which might occur in nature. Such phenomena have been observed in plants and are quite characteristic of gels. This observation may be paralleled in nature by provision of water for the nest by turtles.

TABLE I

MEASUREMENT OF TWO CLUTCHES OF EGGS OF *Elaphe emoryi* ON THE DATE OF EGG-LAYING

Length and width in mm., volume in c. c., weight in grams, and density in grams per c. c.

Egg	Length	Width	Volume	Weight	Density
1	53.0	20.3	13.0	13.05	1.00
2	51.0	21.7	12.0	13.95	1.16
3	55.5	20.5	15.0	15.10	1.00
4	53.0	22.0	13.5	14.15	1.05
5	61.0	20.0	15.0	15.10	1.00
Mean, E-2 Eggs	54.7	20.9	13.7	14.27	1.04
6	59.7	21.1	15.5	16.20	1.04
7	56.8	21.0	14.6	15.20	1.04
8	56.0	20.2	14.9	15.20	1.02
9	57.3	21.4	15.0	16.00	1.06
Mean, E-3 Eggs	57.5	20.9	15.0	15.65	1.04

RESPIRATION

Measurements of oxygen consumption, carbon dioxide production, and respiratory quotient (R.Q.) were made manometrically with a modified Warburg apparatus in which the respiratory chamber for adults was a Scheibler 6-inch desiccator and for eggs, a bottle of suitable size. CO_2 was absorbed by a 20 percent solution of KOH. The apparatus was checked for mechanical errors by: (a) altering the volume through addition and withdrawal of mercury and observing the displacement of manometric fluid; (b) comparing behavior of the empty respiratory chamber with a thermobarometric chamber, which served for barometric and minor temperature corrections throughout the actual accumulation of data; and (c) analyzing the gas over the KOH for CO_2 with a Haldane apparatus. These checks indicate, respectively, a mechanical accuracy of 98 percent, freedom of the data from uncorrected environmental error, and complete absorption of CO_2 by the KOH. Correction for water vapor is made in the conversion formula of Dixon (1935). Observations were made at 26.3±0.3°C.; a period

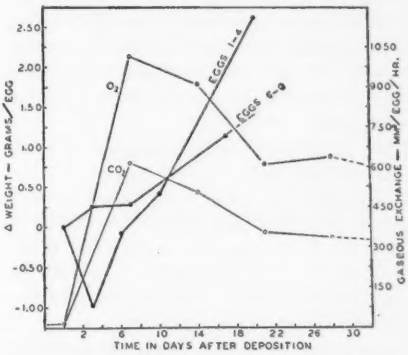

Fig. 1. Exchange of oxygen and carbon dioxide of embryos (light line); weight change as a result of desiccation and hydration (heavy line).

TABLE II

OXYGEN CONSUMPTION, CO_2 PRODUCTION, AND RESPIRATORY QUOTIENT OF TWO ADULT FEMALES OF *Elaphe emoryi*, AND TWO CLUTCHES OF EGGS

Data for adults are expressed as mm³/gram/hr, for eggs as mm³/egg/hr

Stage	O_2	CO_2	R. Q.
Adult			
Prepartum.....	94	62	0.66
Postpartum.....	90	57	0.63
Eggs			
1st week.....	1014	614	0.61
2nd week.....	910	507	0.56
3rd week.....	613	355	0.58
4th week.....	639	336	0.52

of thermal adjustment of the specimen preceded the recording of data, which required 1 to 6 hours. Records were made in the following sequence: O_2 consumed minus CO_2 produced, obtained by observing volume change without KOH; O_2 consumed, by absorbing the CO_2. Subtraction of the former from the latter yielded CO_2 production (Table II; Fig. 1). (Data for eggs were not obtained on a "per gram" basis since the number of specimens was limited

and obtaining embryonic weight would mean sacrifice of the embryo. For purposes of establishing the order of magnitude of the embryonic weight, one was killed at two weeks post-deposition age; it weighed 1.0 g., exclusive of the membranes.)

The R.Q. is consistently low, and no trend in the data is apparent. Zarrow and Pomerat (1937) made respiratory measurements on *Liopeltis* immediately prior to hatching. They found an oxygen consumption rate of approximately 200 mm³/egg/hr and an R.Q. of 0.82. This would point to a continuation of decline in metabolic rate as shown in the present data, and a modification of food supply presumably including a larger amount of protein.

The prepartum rate of O_2 consumption by *Elaphe* was 94 mm³/gm/hr, and the postpartum rate was 90 mm³/gm/hr. Comparison of the two values indicates at best an extremely low intrauterine embryonic rate of O_2 consumption. Contrast between the intrauterine rate of O_2 utilization and that after exposure to the atmosphere is striking, and suggests (1) partially anaerobic development of the embryo in utero, (2) accumulation of an oxygen debt and repayment of it upon exposure to atmospheric O_2, or (3) conversion of fat to carbohydrate, utilizing oxygen for reactions other than complete combustion. These suggestions have parallels in development of amphibians (Brachet, 1934) and the chick (Needham, 1931). In the absence of pertinent analytical data, the writer is reluctant to attempt a more specific explanation.

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The Taxonomic Status of the Tibetan Colubrid Snake *Natrix baileyi*

Edmond V. Malnate

Wall (1907: 617) described a new snake from Tibet as *Tropidonotus* (= *Natrix*) *baileyi*. A study of the characters of this species shows that it must be removed from the genus *Natrix*. All attempts to assign the species to any of the known genera have failed, and so *baileyi* is herewith designated as the genotype of

Thermophis, gen. nov.

Genotype.—*Tropidonotus baileyi* Wall, 1907.

Diagnosis.—A colubrid snake genus distinguished by the following combination of characters: hypapophyses of the vertebrae present only in the anterior part of the body; hemipenis forked, plicate basally, spinous medially, calyculate distally; sulcus spermaticus deeply forked; maxillary teeth 21–24, subequal or progressively larger posteriorly in the series, last two narrowly separated from those anterior; rostral recurved dorsally; anterior nasal plates expanded, projecting dorsally along the rostral edge, almost excluding the rostral from contact with the internasals; dorsal scales well keeled; anal plate divided.

Included Species.—*Thermophis baileyi* (Wall).

Redescription of the Species.—Scale rows 19–19–17; scales well keeled, outer row smooth or faintly keeled posteriorly; reduction in number of rows is effected by the loss of the 4th scale row at points varying from above the 128th to 140th ventrals (4th scale row present for 81.8

percent head and body length in one male, for 60.1 to 64.2 percent, mean 61.9, in five females); apical pits not evident in specimens examined (Wall, *op. cit.*, reports scale pits to be present very indistinctly). Ventrals 201–205, mean 202.8 (5 males); 215–222, mean 219.7 (6 females). Anal plate divided. Subcaudals paired, 107–112, mean 109.5 (4 males), 97–101, mean 98.4 (6 females); a few posterior plates sometimes single.

Rostral wider than high and projected dorsally, its suture with the anterior nasal plate 3 to 6 times longer than that with the internasals. Internasals wider than long, their contact with the rostral very narrow. Prefrontals large, longer than the internasals, extending laterally onto the side of the head. Frontal about three times as long as wide, as long as its distance from the tip of the snout, subequal in length to the interparietal suture. Supraoculars broadly in contact with the prefrontals, their width equal to about two-thirds the width of the frontal. Parietals broad, short, roundly or obtusely truncate posteriorly, their greatest width and length equal, longer than the frontal. Nasal plate divided, the suture passing through the nostril, the anterior portion broadly expanded along the rostral edge and projected dorsally. Loreal elongate, twice as long as high. Preoculars 2; postoculars 3, occasionally 2. Anterior temporals 3–3 in 7 specimens, 3–2 and 2–2 in one specimen each (where only two anterior temporals are present, the plates make contact behind the postoculars, excluding the median temporal from contact with the postoculars); lower anterior temporal small. Posterior temporals 3–3 in six examples, 3–2 in two, and 2–2 in one. Supralabials 8–8 in ten specimens, 9–8 in one; the 4th and 5th (4th to 6th on one side of one specimen) border the orbit; 6th or 7th, largest. Infralabials 10–10 in six specimens, 11–9, 9–9 in one each; the first 5 (or 4, where only 9 infralabials are present) border the anterior chin-shields; 6th (5th in counts of 9 infralabials, 7th where 11 infralabials occur) the largest. Anterior chin-shields longer than posterior pair; posterior chin-shields sometimes split transversely forming two pairs, in which case their combined length is greater than the length of the anterior chin-shields; posterior chin-shields separated throughout their entire length by a narrow scale.

The dorsal ground color is olive green marked with blackish spots and stripes. A vertebral stripe of dark gray-brown is present, enclosing a series of small black spots; posteriorly on the body the spots become obscure and the stripe more prominent. The scales of the first three rows are darkened centrally and form a broad, smoky lateral stripe; the scales of the outer row are edged narrowly with yellow. Occasionally there is an obsolete series of dark spots on the 5th to 7th scale rows. Venter green, paler anteriorly and grayer posteriorly, the ventral plates narrowly edged with yellow laterally and

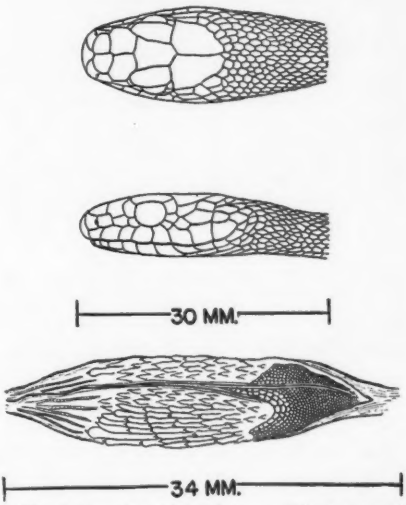

Fig. 1. Dorsal and lateral views of the head, and ventral view of the hemipenis, of *Thermophis baileyi* (British Museum 1946. 1. 12. 52).

along their free edges; the yellow lateral edge forms, with the yellow edge of the outer scale row, a narrow, irregular, ventro-lateral line. Each ventral with a pair of irregularly semicircular, black spots, which are more prominent on the posterior part of the belly (these are connected across the belly but the connecting areas of black are hidden by the overlapping edge of the preceding plate). Head green, mottled with gray, lighter laterally and toward the snout. Supralabials cream yellow, their sutures clouded dusky gray. An obscure gray band extends from the lower postoculars across the upper edges of the 7th and 8th supralabials to the corner of the mouth, and thence back-

ward to join the lateral body stripe. Chin and throat yellow, the mental and anterior labials clouded gray-brown, the posterior labials narrowly edged with gray-green. Caudal pattern similar to that of the body, but much reduced. Juvenile pattern similar to adult, but with the various elements in somewhat greater contrast.

Maxillary teeth 21–24, becoming gradually larger posteriorly in the series, last two narrowly separated from the preceding teeth. Palatine teeth 10–14, subequal. Pterygoid teeth 20–21, gradually decreasing in size posteriorly, last very small. Dentary teeth 27, subequal.

The hemipenis (British Museum 1946.1.12. 52) extends to the level of the 19th caudal, and is forked opposite the 8th caudal; the forks are closely parallel until the point of division of the organ is reached, where each ramus then follows a branch of the organ, but not to the tip; sulcus lips prominent, spinous their entire length. The basal portion of the hemipenis is plicate, the plicae finely spinous. Medially the organ is heavily armed with elongate, fleshy papillae, each of which is tipped with a hard, sharp spicule; these papillae are arranged in longitudinal rows, largest opposite the sulcus; one papilla at the basal edge of the area is strongly enlarged. Forks of the hemipenis are calyculate, the calyces in the fork being large and deep with their edges strongly fringed with small spines; toward the tips of the organ the calyces are smaller and shallower, the spinous fringe narrower. Each area of the organ is sharply defined.

Hypapophyses on the vertebrae are present in the anterior part of the body only, strong near the head, but reducing rather abruptly in size, and lost at the level of the 35th to 40th ventrals (region of the heart).

Total length: largest male 852 mm. (head and body length 632 mm.); largest female 948 mm. (head and body length 711 mm.). Tail/total length ratio: 0.24–0.26, mean 0.248 (five females); 0.25–0.28, mean 0.267 (three juvenile males, one adult male 0.27). Smallest juvenile 280 mm. (head and body length 214 mm.). Head narrow, elongate (head width/head length ratio: 0.48–0.52, mean 0.50 for six adults), not strongly distinct from the neck. Eye large; diameter, if projected forward from the anterior rim of the orbit, reaches the anterior edge of the loreal plate (minimum) or mid-nostril point (maximum).

DISTRIBUTION.—The exact locality for the species is doubtful. Wall, in his original description (*op. cit.*), gives no further locality than Tibet, at about 14,000 feet elevation. All of the known specimens were obtained by Lieutenant F. M. Bailey, apparently from one locality. Specimens now in the British Museum (Natural History) are recorded from "above Gyantze, at 14,000 feet altitude." Two specimens in the collection of the Bombay Natural History Society are listed as being from Lhasa and five others lack locality data. It has not been possible to get more specific data than this so the type locality must remain as noted by Wall, without further restriction.

Thermophis baileyi was found "in the sides of a hot spring, and are never found as far as half a mile distant. . . they are reported not to enter the water, and can be obtained in winter and summer alike" (Wall, *op. cit.*). One female (903 mm., plus) contains six eggs, the most posterior of which measures 12 x 27 mm.

MATERIAL EXAMINED.—BMNH 1946.1.12. 51–59, six females, three males; data on two additional specimens from the Bombay Natural History Society, both bearing the number 90–1. Wall's original description was prepared chiefly from two male specimens, an adult and a juvenile. "More than 20" additional specimens are noted (only 16 specimens have been located), and the variation in ventral and caudal counts for the entire series is given. Lacking more specific designation, all individuals mentioned by Wall must be considered syntypes. The two specimens described in detail by Wall are now specimens 90–1 in the Bombay Natural History Society collection. As first reviewer I designate the adult of these as the lectotype of *Tropidonotus baileyi* Wall (=*Thermophis baileyi*).

DISCUSSION.—*Thermophis baileyi* resembles members of the genus *Natrix* in details of scutellation. The lack of hypapophyses on the posterior vertebrae and the structure of the hemipenis, however, are considered sufficient evidence for separating it from that genus. In all the species of *Natrix* examined the vertebral processes are well developed throughout the body length. In most species there is a tendency for those in the posterior part of the body to be slightly less developed, but in none is the difference in degree of prominence great.

Among the various species of *Natrix* the

hemipenis sometimes bears calyces, but these are uniformly small and shallow with spines issuing from their centers, and they occur over most of the organ's surface. The calyces are not known to be enlarged or fringed. The hemipenis of *N. himalayana* is armed with spines similar in form to the elongate, spine-tipped papillae of *baileyi*; but in *himalayana* these are smaller and more numerous.

The scutellation is similar to that of *Natrix*, except for the dorsal extension of the rostral and anterior nasal plates of *baileyi*; this type of development is unknown among *Natrix*.

The evidence at hand does not permit much more than speculation concerning the phylogenetic history of *Thermophis*. The presumed geographic isolation and the peculiar environmental conditions under which these snakes live supposedly have been important factors in the development of the genus. There is too little information to demonstrate how these factors may have operated. It is possible, however, to outline a hypothesis to fit the data now at hand. Hemipenial and vertebral structure are thought to be the most conservative characters. The structure of the hemipenis, with thick, fleshy spines, the distal area of fringed calyces, and excepting the deeply forked sulcus, is essentially similar to the hemipenis of some Asiatic snakes of the genus *Elaphe* (especially *frenata*, *prasina* and *oxycephala*), and may be interpreted as evidence of relationship to this group. If this possibility be considered, the lack of hypapophyses on the vertebrae of the posterior part of the body is expected. The possession of well keeled dorsal scales and the lack of lateral ventral keeling may have been derived from some type that was also ancestral to the snakes of the genus *Elaphe*, possibly as a reaction to different environmental conditions. The division of the sulcus is unknown in *Elaphe*, but in view of recent studies of the evolution of this character (Bogert, 1940) it is possible that the ancestral form of *Elaphe* had the sulcus forked, and that this has been retained by *Thermophis*.

It may be noted that, in some classifications of the Colubridae, *Natrix* and *Elaphe* are placed in different subfamilies (Dunn, 1928) on the basis of hemipenial and vertebral characters. *Thermophis*, using Dunn's key, would fall in the section Ophiinae (=Xenodontinae). Bogert (*op. cit.*) shows that genera in both the Colubrinae and Natricinae probably have been derived from xenodontine groups. *Thermophis* is intermediate between the colubrine and natricine sections, in that the hypapophyses have been lost but the forked condition of the sulcus has been retained. It is possible that a stock similar (and/or ancestral) to *Thermophis* was ancestral to snakes in both subfamilies, the forked sulcus and posterior hypapophyses being lost in the Colubrinae but retained in the Natricinae.

Gyantze and Lhasa are situated on a high plain (Gyantze Plain or Tsang Po Valley) of 12,000 feet elevation north of the Himalayas, across which the Tsang Po (upper Brahmaputra River) flows. The Himalayas rise 10,000 feet above the valley, and the passes from India are from a few hundred to 3000 feet above the valley floor. This remote area may have been reached by *Thermophis* or, more probably, by a prototype closer akin to *Elaphe* stock, by way of the Brahmaputra River during a time of more favorable conditions.

It is readily admitted that this hypothesis rests on slender evidence; however, a firmer statement must await the time when the relationships among Asiatic snake genera are better understood.

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The name *Thermophis* is derived from *therma* (Latin, hot spring, from the Greek *therme*, warm) + *ophis* (Greek, snake); hence, hot spring snake in reference to the habitat of this serpent.

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Synonymy of the Bathypelagic Fish Genus *Rhynchohyalus*, Referred to the Expanded Family Argentinidae[1]

CARL L. HUBBS

THE contribution by Marion Grey in Copeia (1952 (2): 87–90, fig. 1) on the characters and relations of the aberrant bathypelagic fish genera *Dolichopteryx* and *"Ophthalmopelton"* prompts this supplementary discussion. Recent mid-water collecting by the Scripps Institution of Oceanography and the United States Navy Electronics Laboratory has yielded what appear to be several species of *Dolichopteryx* and probably related genera. Preliminary examination of this material and of the pertinent literature throws some light on the interesting suggestions offered by Mrs. Grey.

Genus *Rhynchohyalus* Barnard

Hyalorhynchus (*nec* Ogilby, 1910).—Gilchrist and von Bonde, 1924: 4 (original diagnosis; haplotype, *H. natalensis*, new species).

Rhynchohyalus.—Barnard, 1925: 130 (description; relations; *Hyalorhynchus* preoccupied). Chapman, 1942b: 272, 301 (classification). Smith, 1949: 97 (diagnosis). Grey, 1952: 88 (classification).

Ophthalmopelton.—Maul, 1946: 62 (characterization, that of new species *O. macropus*). Grey, 1952: 88–89 (comparison and classification).

I see nothing in the descriptions or figures of the 3 reported specimens that definitely indicates generic distinction and therefore feel obliged to synonymize *Ophthalmopelton* with *Rhynchohyalus*.

Rhynchohyalus natalensis (Gilchrist and von Bonde)

Hyalorhynchus natalensis.—Gilchrist and von Bonde, 1924: 4, pl. 1, fig. 1 (description of specimen from Sta. 530, South African Marine Survey, 135 fathoms).

Rhynchohyalus natalensis.—Barnard, 1925: 130 (diagnosis; type was from off Table Bay, South Africa, not Natal). Smith, 1949: 97 (diagnosis). Grey, 1952: 88 (classification; very similar to *O. macropus*).

Ophthalmopelton macropus.—Maul, 1946: 62–65, fig. 23 (description of specimen, from stomach of tuna, brought by fisherman to Museu Municipal do Funchal, Madeira; compared only with *Macropinna microstoma*). Grey, 1952: 88–90, fig. 1 (description of specimen from Bermuda, in open net hauled in about 300 fathoms; comparisons; relations).

The only suggestions of distinction lie in the lower number of dorsal and anal rays and the toothless jaws attributed to the type specimen of *H. natalensis*. The counts require confirmation. The teeth are small and the front of the head is indicated by the figure to have been badly damaged in the type.

RELATIONS

Diverse views have been expressed on the relations of *Rhynchohyalus*. Gilchrist and von Bonde, without remarks, placed the genus in the Salmonidae. In the Zoological Record for 1925 and 1926 Norman listed it under the Argentinidae. Barnard compared it with *Winteria* and provisionally placed both genera in the "Microstomidae." Chapman created for these two genera a new family, Winteriidae, which he included in Berg's suborder Opisthoproctoidei of the Clupeiformes (= Isospondyli). Maul, on the contrary, referred *Ophthalmopelton*, though it is a synonym of *Rhynchohyalus*, to the Macropinnidae. Mrs. Grey accepted Chapman's views, with the further suggestion that "the general resemblance of larval specimens of *Macropinna* to *Ophthalmopelton* and *Rhynchohyalus* suggests a possible close relationship between the

[1] Contributions from the Scripps Institution of Oceanography, New Series, No. 625.

Macropinnidae and the Winteriidae." She further stressed the close similarities in external characters between *Dolichopteryx* and *Ophthalmopelton* as indicative of probable close relationship (in line with a more tentative suggestion by Chapman). I confirm Mrs. Grey's discovery of scales and adipose fin in a species of *Dolichopteryx* seemingly related to *D. longipes* and suspect that *Rhynchohyalus* is not very widely separated generically from such a dolichopterygid.

External characters seem to link the following genera into a rather tight chain: *Dolichopteryx* ⟶ *Rhynchohyalus* ⟶ *Macropinna* ⟶ *Monacoa* ⟶ *Opisthoproctus*. It would seem proper to refer the whole series to a single family, including the recently named nominal families Macropinnidae (Chapman, 1939), Dolichopterygidae (Berg, 1940), and, presumably, Winteriidae (Chapman, 1942b).

I venture an even broader recommendation, namely, that we include in a single family, Argentinidae, not only the families just listed, but also the other "Opisthoproctoidei," as delimited and characterized by Chapman (1942a, 1948, and other papers). The features that integrate this series seem more numerous and more significant than those that are used to separate the several small families currently recognized. The distinguishing features are largely those of such extreme specialization and degeneration as are characteristic of bathypelagic types. The relationships would seem best expressed by including within the Argentinidae the following recognized families (with constituent genera, in addition to *Rhynchohyalus*, discussed above): Bathylagidae (*Bathylagus* Günther and *Leuroglossus* Gilbert); "Microstomidae," more properly spelled Microstomatidae (*Nansenia* Jordan and Evermann, including *Bathymacrops* Gilchrist and *Euproserpa* Fowler; and *Microstoma* Cuvier, probably including *Halaphya* Günther); Xenophthalmichthyidae (*Xenophthalmichthys* Regan); Dolichopterygidae (*Dolichopteryx* Brauer[2]); Winteriidae (*Winteria* Brauer); Macropinnidae (*Macropinna* Chapman); Opisthoproctidae (*Monacoa* Whitley = *Grimaldia* Chapman, preoccupied, and *Opisthoproctus* Vaillant). Little seems to be gained by multiplying the monotypic and oligotypic families within an assemblage so probably natural and so basically compact.

If the family Argentinidae would thus be expanded, there would be little reason to retain the "suborder Opisthoproctoidei," which was originally based by Berg (1940) on the Opisthoproctidae alone, for the two groups would be of equal coverage. Furthermore, it seems incongruous to base the group name on the most bizarre type.

In its radiation, particularly toward short-bodied genera with very highly specialized body form, the Argentinidae (*sensu lato*) parallel the stomiatoid series Gonostomatinae ⟶ Maurolicinae ⟶ Sternoptychinae, which, because of connecting links, I would also refer, as earlier authors did, to a single family, Sternoptychidae.

[2] *Dolichopterygiella* Roule and Angel (1930: 69–76, pl. 4, figs. 90–98) was proposed as a name for a larval type and therefore has no nomenclatorial standing.

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The Production of Underwater Sound by the Northern Seahorse, *Hippocampus hudsonius*[1]

MARIE POLAND FISH

A LARGE northern seahorse, *Hippocampus hudsonius* DeKay, 128 mm. from tip of snout to tip of tail, was kept under observation at the Narragansett Marine Laboratory between October 1, 1951, and February 15, 1952. The experimental tank was monitored by hydrophone and magnetic tape recorder.

RECORDED SOUNDS.—Fourteen sounds recorded for analysis during this period were loud clicks, similar to the snapping of finger against thumb. Their frequency distribution extends between octaves 0 to 50 cycles per second (cps) and 2400 to 4800 cps, with maximum energy in the 300 to 600 cps and 400 to 800 cps bands. The average of two typical sounds, with frequency spectrum extending from 250 to 1800 cps, is shown in Fig. 1. The maximum overall pressure recorded is 22.6 dynes per square centimeter, at a distance of six inches from the hydrophone.

STIMULATION TO SOUND PRODUCTION.—Spontaneous soundmaking was limited to the first two days and seemed to be associated with strangeness of environment. Although held elsewhere in captivity for two weeks previously, the specimen immediately reacted to the new location with a vigorous snapping, repeated at intervals of approximately one-half to three-fourths of an hour during the first day. After the first burst of five, the snaps were made singly, doubly, or in a series of four spaced about one second apart. Preceding each sound or burst of sounds, the seahorse cruised the length of the tank one or more times in its characteristic upright position, propelled by the rapidly vibrating ear-like pectorals and the rudder-like dorsal fin, its prehensile tail curling tightly up from a horizontal position and down again persistently. Then the tail attached to a branched twig, and, after a short period in which the fins were collapsed and only slight movement in the gill region was evident, the sound was made, accompanied by the head motions described in the next section. Following its soundmaking, the fish remained stationary for some minutes except for a slow and constant movement of the head from side to side.

Living plankton was available in the tank during the period of captivity, and the seahorse appeared to search for additional food among the detritus on the bottom, but no sounds were associated with feeding. Attempts at irritation with a glass rod were greeted by the mere drawing downward of the head and a tight coiling of the tail; no outward fear was induced. Tapping on the glass wall, or even sudden motions close by without touching the tank, were sufficient to cause a quick jerking of body and subsequent recoiling. But there was no animal sound.

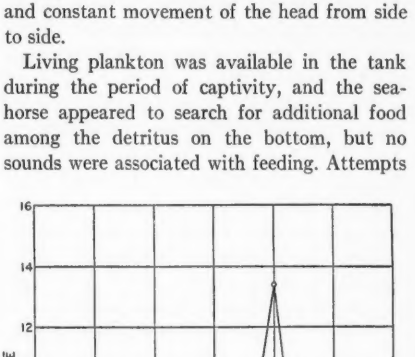

Fig. 1. Spectrum of typical *Hippocampus hudsonius* sound. From average of two snaps produced by a 128-mm. female.

Raising the temperature of the water over a period of two hours from 65° to 75°F. resulted in slowing the specimen's activity to a standstill. Sudden removal from the 75° water to

[1] Contribution No. 4 from the Narragansett Marine Laboratory, Univerrity of Rhode Island. This paper is based on research conducted under contract with the Office of Naval Research.

another aquarium at 65° induced immediate swimming and sound production.

It is inferred that, for this one fish at least, sound may be used in new surroundings for orientation, perhaps to find the whereabouts of others of its species. This specimen was a female, and was said to have spawned eggs in captivity during the previous week, but the author cannot verify that report.

Previous reports of soundmaking among seahorses are limited to a European species, *Hippocampus brevirostris* Cuvier, in which both sexes allegedly make a monotonous noise analogous to that of a tambour, especially during the breeding season (Dufossé, 1874). The fact that copulation occurs among members of this family, at which time the eggs are deposited by the female in the brood pouch of the male, lends plausibility to the theory that a mating call may be used to bring individuals together.

An amusing story concerns an artist who was sketching two seahorses in separate jars. "Suddenly a sharp little snapping voice called at short and regular intervals from one container, followed by a response from the other. Gill (1905) concludes that they were 'thus conversing or signalling to each other.'

"Uchida in a 1939 radio broadcast in Japan described a similar episode where two seahorses in separate jars conversed for some time 'as if they were exchanging telegraphic code'." (Fish, 1948).

MECHANISMS INVOLVED IN SOUNDMAKING.—All of the recorded sounds were made in the same way. The specimen was observed to lift its head several times from the usual position at right angles to the body in a motion resembling "stretching of the neck." Then finally the head flexed as high as possible, so that its top was almost in a straight line with the edge of the back. The coincident snapping sound appeared to be stridulatory in origin, and its high frequency corroborated this theory.

Examination of the dead specimen showed a loose articulation between the posterior margin of the skull and the anterior margin of the coronet, which is a star-shaped, ossified crest mounted in a socket-like base. (Whether this structure represents a true skull bone, or whether it is a modification of a spiny dorsal fin support, has not been definitely determined.) When the seahorse's head was extended moderately, the articulating bony edges could be seen to rub together, but when elevated more sharply, the coronet overlapped the other bone. Dissection showed adequate muscular equipment to permit such movement in the living fish. It is suggested, therefore, that the "finger-snapping sound" results when the skull edge slips forcibly under the coronet, or, more likely perhaps, when it snaps out. Vibrations thus set up may be transferred to and amplified by the air bladder. Burkenroad (1931) observed a click, described as quite similar to that of an elaterid beetle, when the pipefish *Syngnathus louisianae* Günther repeatedly snapped its head sharply upward.

In the example cited by Gill (1905), sound was attributed to the muscular closing and sudden expansion of the lower jaw of the seahorse. Possibly this is another noisemaking mechanism, but the author tends to believe that the sound produced, which is described as a snapping resembling in tone and strength (without benefit of hydrophone and amplifier) that of the scarlet prawn, *Alpheus ruber* Milne-Edwards, could not be made by the short, toothless jaws at the end of the seahorse's narrow, tube-like snout. We noted rapid movement of the mouthparts along with almost imperceptible quivering of the whole body during the head stretching, but greater vibratory movement of the same type at other times produced no sound.

ACKNOWLEDGEMENTS.—Acknowledgement is made of the valuable assistance of William H. Mowbray in the sound analyses, and of Prof. Robert A. DeWolf in dissection of the specimen.

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NARRAGANSETT MARINE LABORATORY, UNIVERSITY OF RHODE ISLAND, KINGSTON, RHODE ISLAND.

Breeding Behavior, Early Embryology, and Melanophore Development in the Anabantid Fish, *Trichogaster trichopterus*

WILLIAM RAY HODGES AND ELLINOR H. BEHRE

THE blue gourami, *Trichogaster trichopterus* (Pallus), belongs to the family Anabantidae in which most of the members are "bubblenest builders." This family is in the suborder Labyrinthici, which is characterized by the presence of a chamber above the gills for the retention of air for breathing. The blue gourami, suggested as a reliable egg-laying teleost by Rugh (1948), has become a useful species for experimental work and class-room demonstration. There is, however, no detailed description or experimental analysis of the embryonic development except for work in progress at Oklahoma A. and M. College by Mr. Robert H. Ingersol (see also Ingersol, 1951), and nothing on its very interesting breeding behavior aside from brief accounts in aquarium books. This study attempts to fill in some of the gaps in our knowledge of this species, especially its breeding behavior and early embryology, and the time and manner of origin and development of the pigment cells.

Laboratory Procedure

The fish were isolated in aquaria, ranging in capacity from seven to ten gallons, with a sand-covered bottom, lake water to a depth of five inches, and a few aquatic plants. Since these animals are air breathers, aeration is not necessary; further, the use of an aerator tends to destroy even the best built nest. The fish were well fed on a diet of prepared tropical fish food, in daily quantity sufficient to be consumed within about ten minutes. It is not necessary to keep the water at a constant temperature; a daily range between 77° and 80°F. is adequate.

Shortly after spawning occurs the eggs with their attached bubbles may be removed from the aquarium and placed in a small finger bowl by means of a pipette; they may then by freed from any attached bubbles and isolated on shallow depression slides for observation. Continuous observation of one individual at a time is possible for study of steps in embryogenesis and migration of melanophores; observations of single embryos may be continued on slides over a period of four or five hours.

Breeding Behavior

The outstanding feature of the breeding of this fish is the construction of a floating nest of bubbles in which the eggs are placed when laid, and where they are kept through hatching and early larval stages. While the eggs of some of the other fishes in the same order require the support of the bubbles to prevent them from sinking to the bottom of the aquarium, the eggs of *Trichogaster trichopterus* float. The bubbles for the nest are formed as follows: the fish come to the surface and draw air into the mouth, where it is enveloped in mucus. These bubbles are then released beneath the surface of the water in a desirable location, usually around some floating aquatic foliage; since in the aquaria used there was little vegetation, the nests were built in corners. When released, the bubbles float to the surface and tend to stick together. Nests sometimes cover as much as 12 square inches of surface area and are at some points as much as ¾ inch in depth, much of this occurring above the water line. The nest-building activity is generally attributed to the male. However, the female will occasionally blow bubbles in some region other than that of the nest, the male usually keeping her herded into a far corner of the aquarium. The nest-building is an indication of the breeding condition and is accompanied by color changes. Normally the species is a silver-blue, but turns steel-blue or almost black when excited or sexually stimulated. The spots, one pair on each side, are normally black, while during the sexual color change they become devoid of color. Sexual activity is further correlated with great increase in the intensity of colors on the fin.

Spawning is very rarely a spontaneous occurrence even when both male and female

appear to be in proper condition. The courting is conducted by the spreading of the fins, with occasional nudging of the side of the body by the mouth of the other animal, either male or female. There is usually much chasing and possible nipping of fins. Many times, in these studies, the female was on the offensive, probably because of the smaller size of our males. Finally, however, the female always becomes passive and is generally forced by the male to remain in a corner of the aquarium at the opposite end from that occupied by the nest. The male now rebuilds the nest, which, if already completed before the courting activity, has probably been partially destroyed. When the nest is satisfactory to the male he either turns in the direction of the female and she, being ready to spawn, swims under the nest, or if she does not respond to this signal the male herds her under the nest. The male then proceeds to take a position anterior to and at right angles to the female, who is at an angle of approximately 30 degrees from horizontal, with the head higher than the tail. The male moves back and forth a short distance, stroking the under part of the body of the female with his dorsal fin. Finally, when the proper moment arrives, the male curves his body around the middle of the body of the female, his head and tail meeting on the dorsal side of the female; this is the "embrace." The body of the female is squeezed and both fishes roll over and while in this position there are vibrations of the male's body and relaxation, at which time the eggs are laid and fertilized. Immediately thereafter they rise to the surface. The female is then released and both fishes sink towards the bottom of the aquarium. The male then chases the female away from the vicinity of the nest and begins to pick up the floating eggs. He takes them into his mouth and blows them into the nest along with numerous bubbles. If the spawning activity does not result in the laying of eggs the male chases the female around the aquarium, sometimes pushing her with such vigor that she strikes the side of the tank with audible force. From a few to many eggs are laid at a single embrace, this procedure being repeated several times. After the spawning is complete the female is forced to remain away from the nest while the male is continuously active, repairing the nest by the addition of bubbles beneath the eggs. Sometimes the eggs, immersed in bubbles, are completely above the water surface.

After spawning is completed it is advisable to remove the female to another tank, since, when she is allowed to remain in the same aquarium with the male and the embryos, the male spends much of his time driving her away from the nest. However, on several occasions the female was not removed and no particular damage was noticed, either to the female or to the embryos.

When the embryos hatch, the male begins the never-ceasing task of collecting the babies from all regions of the aquarium where they may have strayed and replacing them in the bubble-nest. As soon as the babies are actively swimming it is best to remove the male, and also the female if this has not already been done. On one occasion, the male fish consumed all of the several hundred babies present, in the short period of two hours.

Since the blue gourami is a tropical fish, it might be expected to show no close correlation of sexual season with light or temperature, and in this study no experiments were attempted to test such a possible correlation. Casual observation indicated that the fish may breed and produce offspring at intervals of two weeks over a period of at least four months. It is felt that no generalization can be made from this observation.

Raising the babies presents a special problem. Their small size makes necessary a diet other than even the finest prepared foods. For the first two weeks it is necessary to add water containing unicellular algae, and after that time the addition of protozoans is necessary. When two months old, or perhaps a little earlier, the fry will begin to eat prepared dry food of the micrograin size. More rapid growth is said to be caused by "forced feeding" with sifted daphnids.

General Embryology

The Unfertilized Egg.—It is not possible to obtain unfertilized ova due to the manner in which spawning and fertilization occur. There are occasionally eggs which are opaque when examined immediately after spawning. These show no indications of normal developmental processes and it is assumed that these eggs have not been fertilized. In one case in which

development did not occur in any of the eggs of a spawning, the average size was .87 mm. and the extremes were .79 and .91 mm. These eggs are opaque, like all eggs that fail to develop, even those of normal broods.

The Fertilized Egg.—The fertilized egg is transparent and numerous fine oil globules appear of considerable variation in size. These globules seem to be segregated from the yolk material and are fairly well dispersed throughout the yolk, showing no particular pattern of distribution. The cytoplasm of this egg is at first spread evenly over the entire surface of the yolk. Within 30 to 45 minutes it streams to one pole to form a raised blastodisc; this, however, remains continuous with a thin layer of cytoplasm surrounding the yolk. The blastodisc after concentration covers the animal pole, over roughly one-third of its area. The total amount of yolk is relatively small; the ratio of cytoplasm to yolk is consequently greater than in *Fundulus heteroclitus* (Oppenheimer, 1937) but approximately the same as in *Brachydanio rerio* (Roosen-Runge, 1938).

Immediately after fertilization the egg membrane is loose and wrinkled, but at about the time when the blastodisc becomes conspicuous the membrane becomes distended and turgid.

The average size of the fertilized eggs for all the broods used in this work was .79 mm.; the range in average sizes between the different broods was .76 to .87 mm. This represents a rather wide range of variation and appears to indicate that there is ovulation of mature ova of varying sizes at one spawning. This is probably a result of the continuous rather than cyclic development of ova; in this way the older ova would have accumulated more yolk than the younger ones.

Early Cleavages.—The first cleavage plane transects the blastodisc vertically, dividing it into equal halves. As cleavage progresses the outer surface becomes somewhat wrinkled. The average time for the completion of the first cleavage is 40 minutes from the time of fertilization. The second cleavage plane is also vertical and is at right angles to the first, resulting in four blastomeres of equal size. The second cleavage is completed, on the average, 11 minutes after the first. The third cleavage occurs in two planes which are vertical, and parallel to the first cleavage plane. There result eight equal blastomeres arranged in two rows of four cells each. The time required for the completion of this cleavage is nine minutes. As a result of the fourth cleavage the blastodisc is now divided into 16 blastomeres with cells arranged in 4 rows of 4 cells each. Though the cleavage planes were not accurately observed in the process of formation, it seems fair to assume that the fourth cleavage is again in two planes parallel to the second cleavage plane. This stage was reached about 11 minutes after the completion of the fourth cleavage.

The considerable lapse of time between the time of fertilization and the first cleavage of the blastodisc is especially marked when compared with the rapid rates of later cleavages. It has been suggested by various workers that the cytoplasm is mingled to some extent with the yolk material of the unfertilized egg. The time required for the cytoplasm to become concentrated at the surface of the yolk and move to the pole to form the blastodisc apparently accounts for this delay of the first cleavage. It should be noted that subsequent cleavages follow with no significant variation of time.

Initial Expansion of Blastoderm.—In the early blastula stage the blastoderm resembles the 32-celled stage except that the cells are smaller and more numerous. The marginal cells are open peripherally and are continuous with the periblast. As cleavage continues, the blastoderm expands over the yolk mass and periblast, and becomes noticeably flattened by the time that the blastoderm has covered about one half of the yolk mass. This expanding area does not progress at the same rate in all directions. The irregular "frilled" edge of the blastodisc may be interpreted as the result of irregular cleavages and differential growth at the periphery.

Formation of Germ Ring and Embryonic Shield.—The blastoderm continues to expand over the yolk and cells begin to pile up at this expanding margin. Just when the blastoderm has expanded to extend beyond the equator of the yolk mass and is converging toward the vegetal pole, the germ ring becomes conspicuous; this is about seven hours after fertilization. With exception of irregularity in rate of spread of the blastodermal rim (see above), the material studied behaves in definite agreement with the observations of

TABLE I

DEVELOPMENTAL STAGES OF *Fundulus heteroclitus* AND *Trichogaster trichopterus*

Figures below each species represent the age in hours for the corresponding developmental stage. Data for *Fundulus* from Solberg (1938).

Fundulus	*Trichogaster*	Developmental Stage
0	0	Fertilized egg.
..	35 to 45 min.	Cytoplasm localized.
1	....	1 cell.
1½	40 min.	2 cell.
2	51 min.	4 cell.
2½	1 hr.	8 cell.
3	1 hr., 10 min.	16 cell.
3½	1 hr., 21 min.	32 cell.
4	....	64 cell.
4½	....	128 cell.
5	....	256 cell.
5½–6	....	Early high blastula.
7–9	....	Late high blastula.
10–12	....	Flat blastula.
13–15	....	Expanding blastula. Blastula enlarges.
16	....	Gastrulation begins. Early gastrula.
18	....	Blastoderm about one-third over surface of yolk.
19½	....	Blastoderm about one-half over surface of yolk. Middle gastrula.
21	....	Blastoderm about two-thirds over surface of yolk.
22	....	Blastoderm about three-fourths over surface of yolk.
..	7	Germ ring forms.
23	....	Embryonic shield condenses to form keel.
..	8½	Embryonic shield well formed.
24	12½	Optic vesicle first visible as expansion of fore-brain. Large yolk plug.
25	....	Small yolk plug.
26	....	Blastopore closes.
27	....	First somites formed.
28	....	Four somites.
31	....	Optocoele develops.
33	....	Auditory placode forms. Optocoele connects across brain.
34	....	Optic cup forms, and lens develops. Neurocoele develops. About 10 somites.
38	....	Expansion of mid-brain to form optic lobes.
42	14	Melanophores first appear on yolk.
..	14½–15	Body melanophores first appear.
..	18	Melanophores show characteristics of mature cells.
44	....	Heart pulsates. No circulation. Hindbrain enlarges.
..	18–20	Initial heart beat.
46	....	Circulation begins, through dorsal aorta and vitelline vessels.
48	....	Circulation through ducts of Cuvier.
60	....	Otoliths develop.
72	....	35 somites developed.
78	....	Pectoral fin bud appears.
84	....	Retinal pigmentation begins. Urinary vesicle formed. Caudal fin begins to develop.
90	....	Liver develops. Cartilage begins to differentiate.
102	....	Pectoral fin round.
108	....	Lens of eye just obscured by retinal pigmentation.
114	....	Pigmentation of peritoneal fin.
120	....	Circulation in pectoral fin.
126	....	Fin rays in caudal fin visible.
144	....	Air bladder develops.
168	....	Neural and hemal arches in tail vertebrae are developed.
192	....	Head flexure begins to straighten out.
216	....	Head flexure nearly straightened out.
240	....	Mouth opens.
264	22–24	Hatching. Pigmentation of bladder.
288	....	Yolk is completely absorbed.

Trinkhaus (1951) on epiboly in *Fundulus heteroclitus*.

The embryonic shield arises from that portion of the blastoderm in which the thickening is greatest. It is well formed at eight and one-half hours after fertilization, and the closure of the blastopore is then not quite complete.

Appearance of Optic Vesicles.—While the embryonic shield appears as if contracting to form the embryo, the first visible differentiation is the expansion of the forebrain to form the optic vesicles, at about 12 and one-half hours.

Solberg (1938) established norms for the occurrence of certain organ primordia in relation to the total hatching period (average hatching time, 264 hours) of *Fundulus heteroclitus*. The figures for this species when translated into percentages are as follows: 9.09% for optic vesicles, 13.15% for yolk-sac melanophores, and 16.66% for initial heart beat. It is interesting to note for *T. trichopterus* the corresponding figures (average hatching time, 23 hours): 54.45% for optic vesicles, 60.86% for yolk-sac melanophores, and 82.60% for initial heart beat (Table I).

From these figures it can readily be seen that though the difference in the percentages of total time between the development of optic vesicles and yolk-sac melanophores is well correlated for the two species, there is an outstanding difference in the time between the appearance of the yolk-sac melanophores and initial heart beat when compared in the above manner.

Development of Melanophores

Development of Yolk-sac Melanophores.—The melanophores of the yolk-sac are the earliest to appear in the developing embryo. These are first observed when the embryo is about 14 hours old, and are initially very pale and barely visible (Fig. 1). The cell membranes very rapidly become well defined, but at first there are no large melanin granules. The melanophores are most numerous near the trunk of the embryo and are less frequent toward the ventral surface of the yolk-sac. They increase rapidly in number, and at the 14-hour stage, looking at the embryo from a lateral view, there are usually 10 to 20 melanophores on one side of the yolk-sac. Within the next two hours the number increases to 75 to 100 cells (Figs. 2 and 3). These follow the same pattern of distribution as did the earlier melanophores, tending to concentrate near the trunk. By this time each melanophore possesses distinct pigment granules and a visible nucleus.

In the early stage of differentiation, the melanophores do not have the characteristic appearance of those of the later embryo or of the adult animal; the shape of the cell and the density of the pigment granules are variable. Amoeboid movement of the early melanophores is readily observed.

The melanin granules can be seen to stream into the processes, which are extended during this movement; but this is not the typical expansion of fully developed melanophores. The processes do not extend in all directions from the cell body; they are largely in the direction of movement. Stockard (1915) reported that in *Fundulus* sp. the melanophores, at least in the neighborhood of the blood vessels, could be seen to undergo fusion. In our material it was observed that melanophores do come into very close contact temporarily. Often two or more cells will move together as if to form a syncytium. Upon continuous observation of the melanophores, it will be seen that this is not a permanent condition. Occasionally, when melanophores that are on contact move apart there is an apparent change in size from that observed before contact; one cell appears larger and one smaller than originally. This apparent change in size of melanophores after contact is probably the result of a change in shape, thus producing the appearance of a transfer of cytoplasmic material.

About four hours after the initial appearance of the melanophores they begin to show the characteristics of fully developed cells. The nucleus is centrally located and the cell body is surrounded by processes which are approximately of the same length.

It is apparent upon actual count that at this stage of development there are fewer melanophores on the yolk-sac than previously, and those present are much larger than they were in the earlier stages (Fig. 4). This is interpreted as a result of the growth of the embryo and the reduction of the size of the yolk-sac, whereby the melanophores are transferred passively from the yolk-sac onto the body of the embryo. Observations on the living embryos support this conclusion.

At the time of the initial heart-beat, at 18

to 20 hours, the large yolk-sac melanophores still maintain the locomotive power. They are rather uniformly scattered and it is only after hatching that they again show the tendency to come in contact with one another.

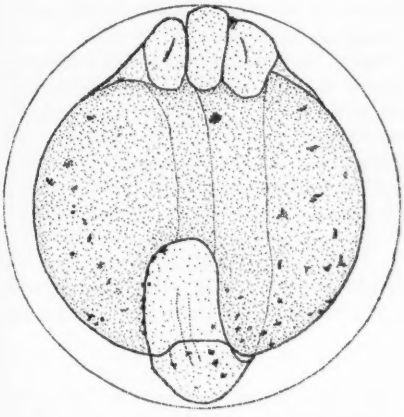

Fig. 1. 14 hours old. Initial appearance of melanophores.

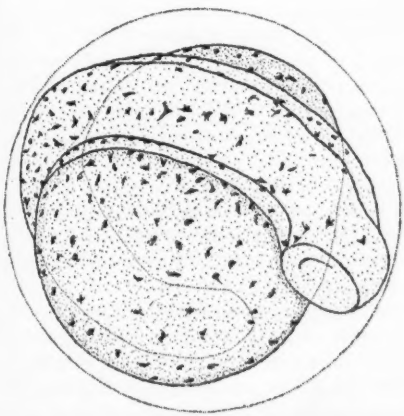

Fig. 2. 16 hours old. By this time there has been a considerable increase in the number of melanophores present.

Gilson (1926) observed the dense aggregation of early yolk-sac melanophores about the vitelline vessels in *Fundulus heteroclitus*. There is no indication of this phenomenon in the blue gourami. This is not due to inactivity of the melanophores, for at the time of the development of the vitelline vessels movement is clearly indicated by the occasional contact between two or more of these cells after circulation has begun.

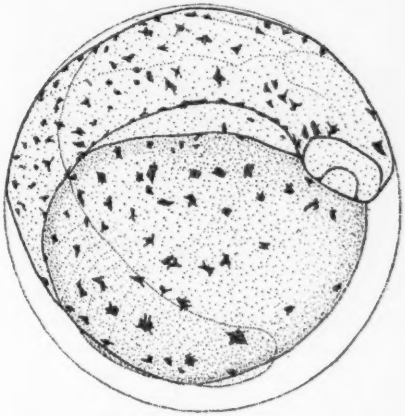

Fig. 3. 17 hours old. Note increase in size of the melanophores.

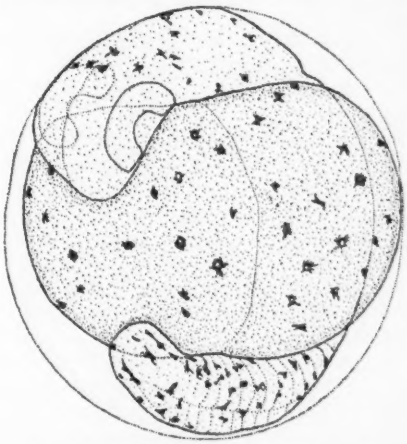

Fig. 4. 18 hours old. The number of yolk-sac melanophores has decreased. Note arrangement of melanophores in tail region.

Development of the Body Melanophores.—The first melanophores of the embryonic body are visible shortly after those of the yolk-sac, about one-half to one hour. There are initially one or two pigment cells in the region of the head and 15 to 20 scattered over the midtrunk (Fig. 1). Increase in number is rapid and, as segmentation occurs, the melanophores are

seen to lie between the somites, giving the appearance of metameric arrangement (Fig. 4). There is, however, no set pattern as to the number of melanophores on each segment and some segments are devoid of such cells.

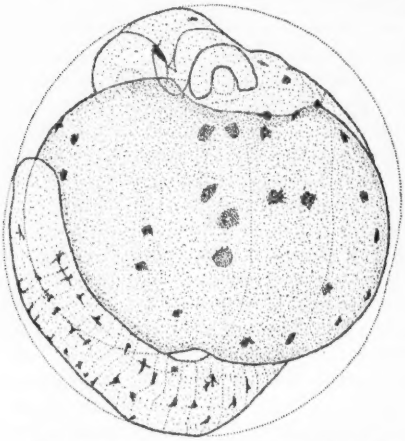

Fig. 5. 19 hours old. Yolk-sac melanophores have decreased in number and longitudinal rows of body melanophores are now noticeable. Vitelline vessels are visible.

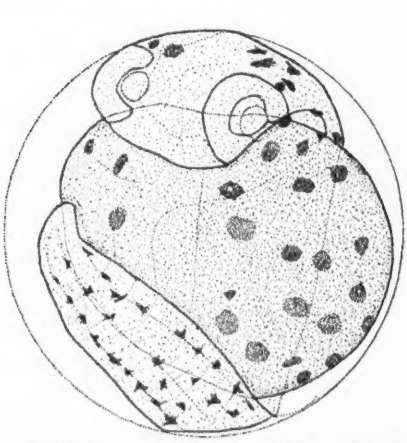

Fig. 6. 22 hours old. Vitelline vessels have become enlarged. Yolk-sac melanophores are apparently mature at this time.

The arrangement of the melanophores in the posterior trunk and tail region is not metameric, though it appears so upon superficial observation; the number of melanophores per somite is variable and the arrangement is not constant. The melanophores forming the longitudinal bands in the tail region at the time of hatching presumably arise *in situ* rather than by migration into those regions; however, they are capable of slight amoeboid movement. There are still other melanophores, present between these longitudinal rows, which have no apparent orientation.

By the time of hatching, 22 to 24 hours after fertilization, the majority of the melanophores are arranged in longitudinal rows in the tail region; but there are still some which have no apparent orientation (Figs. 5 and 6). After the embryo hatches the longitudinal pigment bands become more definite; there is one band on the dorsal surface of the tail, two bands on the ventral surface, and one lateral band on each side. There are still other melanophores which lie irregularly between the distinct rows.

Summary

The major factors of interest concerning the breeding behavior of *Trichogaster trichopterus* are the "bubble-nest," in which the eggs are placed when laid, the "embrace," during which the eggs are laid and fertilized, and the characteristic color changes which appear during sexual activity. There is a wide range in the sizes of fertilized eggs which is fairly constant for all broods.

The general embryonic development follows the pattern which has been described for other teleosts; however, the relatively small amount of yolk is the cause of slight irregularities in development when compared with the development of teleosts with a relatively greater amount of yolk.

The length of time required for the completion of the first cleavage is considerably greater than that necessary for subsequent cleavages. This is probably due to the time required for concentration of blastodisc material at the animal pole.

Appearance of the yolk-sac melanophores at 14 hours is followed immediately by the appearance of the body melanophores; both systems are well developed before the initial heart beat at 18 to 20 hours.

Temporary contact between yolk sac melanophores, not, however, involving actual fusion, results from amoeboid movement. By the time the embryo is 18 hours old there has been

a reduction in the number of melanophores which were at one time present on the yolk-sac. This is explained by the expansion of the embryo and the reduction in the size of the yolk-sac, melanophores being transferred from the yolk-sac onto the body of the embryo.

There is no indication of the aggregation of yolk-sac melanophores about the vitelline vessels such as has been described in *Fundulus heteroclitus*.

The body melanophores of the posterior trunk and tail region are not metamerically arranged. There are longitudinal bands of melanophores present, but the orientation of the pigment cells is not consistent for each somite.

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Periodicity of Growth and Change of Condition of Brook Trout (*Salvelinus fontinalis*) in Three Michigan Trout Streams

Edwin L. Cooper

One of the lesser known aspects of the life history of the brook trout, *Salvelinus fontinalis* (Mitchill), concerns the periodicity of growth and the concurrent changes in condition from one season to another. Previous attempts to obtain sufficient data for a comprehensive study of these phenomena were largely futile due to the inability to "find" the brook trout during cold weather and to the lack of interest in working under adverse climatic conditions. Recent advances in techniques of collecting trout during the winter months by using direct-current electro-fishing have made such a study of trout on a year-round basis more efficient. The present discussion is based on a series of collections of brook trout from portions of three Michigan streams taken from March 27, 1951, to March 11, 1952, approximately at monthly intervals, with about 100 trout per collection. These streams are Hunt Creek in Montmorency County, the Pigeon River in Otsego County, and the North Branch of the Au Sable River in Crawford County. In each stream, a portion was selected which was known to contain a fair to large population of naturally spawned brook trout. Other factors considered in their selection were the lack of ice cover during severe winter weather and easy access by road during periods of heavy snow. The sections designated for sampling were each approximately 500 yards long.

Methods.—The fish were collected with a direct-current shocker, anesthetized, measured, and weighed; scale samples were taken and the fish were returned to the stream. Many individual fish were recaptured and sampled during subsequent visits as evidenced by the marks left by scale sampling. The population density appeared not to fluctuate a great deal during the year although usually more effort was necessary during the winter to obtain a sample of about 100 trout. The portions of the stream frequented by trout changed radically with the change in seasons. During the spring, summer and fall, the trout were found in pools, on riffles, or near cover in the main part of the stream. During winter, these portions of the stream were completely deserted and the fish

could be found only in places out of the current, under banks, in piles of stones and rocks, or amid heavy concentrations of brush and debris. The effect of direct-current electro-fishing in drawing fish to the positive electrode from hiding places in this heavy cover was the dominant factor responsible for numerically adequate collections of fish in winter. Previous attempts to collect fish from these streams during winter with seines or with alternating current shockers were ineffective.

The comparisons of growth rate between streams on different dates of collection have been based on the average length of all the fish in a sample of a particular year class. Periodic samples were taken in all three streams on the same date or at time intervals of not more than 3 days, so that average sizes would be directly comparable. Age determinations were made from samples of scales. Collecting was limited to direct-current electro-fishing since it has been shown that angling selects the faster-growing individuals of each age group and angling samples are thus not directly comparable to samples taken by other methods (Cooper, In press). Comparisons have been limited to the 1950 and 1951 year classes; fish that were in their first and second years of life. These limitations were necessary to ensure the adequacy of sampling, and also to eliminate a systematic bias due to sampling a population that was being selectively cropped by fishermen. In comparing samples of the 1948 year class of brook trout in the Pigeon River taken by angling, Cooper (*op. cit.*) demonstrated a gradual decrease in calculated growth to the first annulus of about 25 percent from the individuals appearing in the catch in July, 1949, to the fish caught a year later. This latter source of error was not entirely eliminated, for a 7-inch minimum size limit on Hunt Creek and on a small portion of the Pigeon River enabled fishermen to remove some of the individuals of the 1950 year class that were more than 7 inches long. On the North Branch of the Au Sable River, a 10-inch minimum size limit prevented the exploitation of the 1951 and 1950 year classes almost entirely during the period of the study. On most of the section of the Pigeon River, a 9-inch minimum size limit gave protection to the 1951 and 1950 year classes.

GROWTH RATE.—In all three streams the growth rate increased rapidly during the last week in April or first week in May. It remained rapid during May and June, slowed up considerably during July, August, September and October, and practically ceased during November, December, January, February and March (Fig. 1 and Table I). The North Branch of the Au Sable River exhibited the fastest growth rate for both year classes, followed by the Pigeon River and Hunt Creek, in that order. Because of the lack of growth during the period November through March, the last five collections in each stream may logically be combined to give a more adequate estimate of the differences in length attained by the two year classes in the three streams. Thus the average sizes of the 1951 and 1950 year classes of brook trout for the North Branch of the Au Sable River at the end of the 1951 growing season were 4.15 inches and 7.87 inches, respectively. For the Pigeon River these values were 3.87 inches and 6.26 inches; and for Hunt Creek, 3.41 inches and 5.78 inches (Table I). The differences between the means for the three streams are highly significant with values of "t" ranging from 4.6 to 26.4. There was considerable variation in growth rate of individual fish in all the samples, and the range in size, especially of the 1951 year class, increased throughout the season. For example, 71 of the 1951 year class from the North Branch of the Au Sable River on April 11, 1951, varied in total length from 0.8 inch to 1.1 inches. On January 2, 1952, 69 individuals of the same year class ranged from 2.8 inches to 6.2 inches in length. In Hunt Creek, where the average growth rate is considered quite slow, 53 fish of the 1951 year class varied in length from 2.6 inches to 5.2 inches on February 1, 1952, and 39 fish of the 1950 year class were from 4.4 inches to 7.3 inches on July 26, 1951. This rather large amount of variation in growth rate is important to note because it appears that the fast-growing individuals of each year class furnish the bulk of the anglers's catch in streams exhibiting a slower than average rate of growth. Average growth rates therefore do not portray adequately the contribution to the angler by individual year classes, without further information as to the amount of variation within samples. In Hunt Creek, the growth rate of the trout indicates that the average fish does not reach legal size until its fourth summer, yet much of the catch is composed of fish in their third

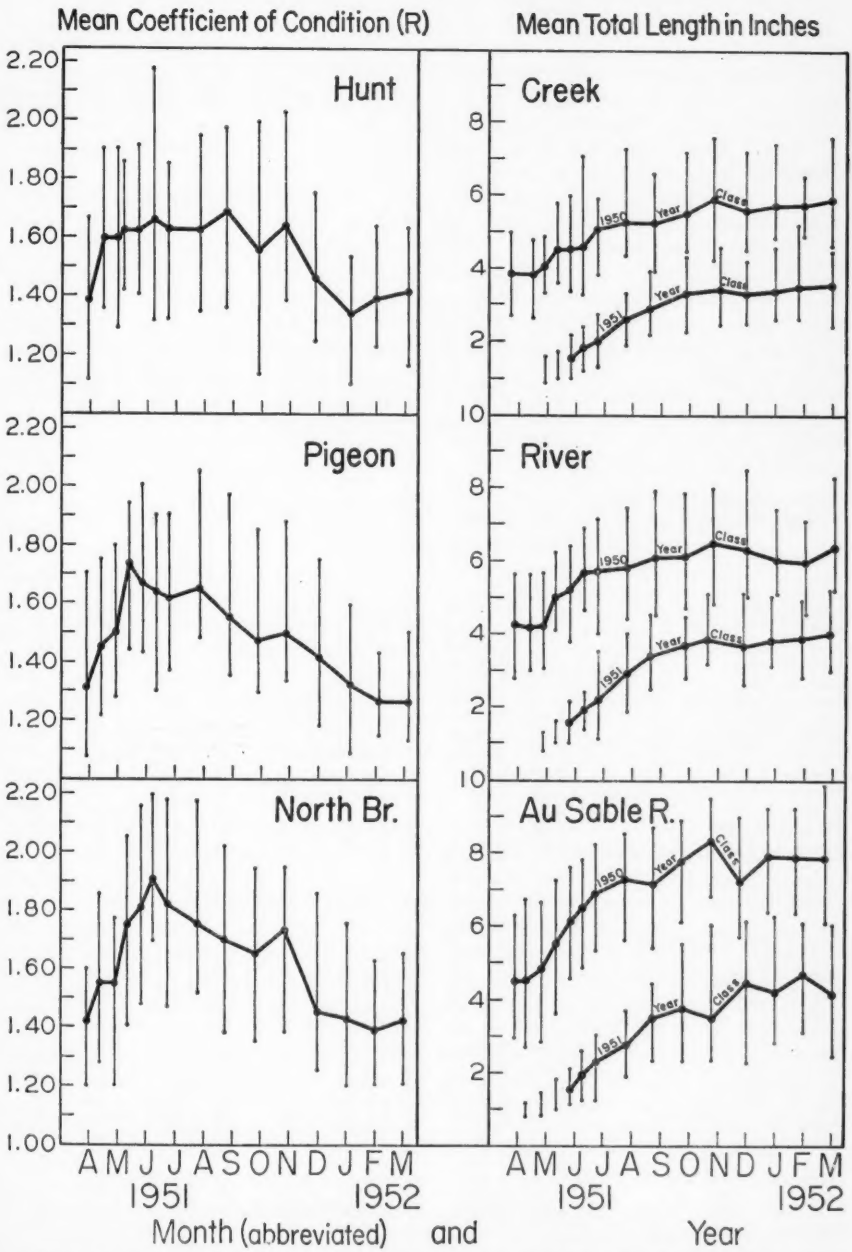

Fig. 1. Curves for mean coefficient of condition (R) and for mean total length in inches, with ranges given as vertical lines, for wild brook trout in monthly collections from three streams in Michigan (data, in part, from Table I).

Table I

Periodicity of Growth and Change in Condition of Wild Brook Trout from Hunt Creek, Pigeon River and North Branch of the Au Sable River from March 27, 1951, to March 11, 1952

Locality and date	1951 year class			1950 year class			Condition factor – R		
	Mean length	Standard error of mean	Number of individuals	Mean length	Standard error of mean	Number of individuals	Mean condition	Standard error of mean	Number of individuals
Hunt Creek									
March 28, 1951	...	...	0	3.85	0.10	32	1.38	0.020	35
April 13, 1951	...	...	0	3.83	0.07	52	1.61	0.015	62
April 26, 1951	...	...	15	4.03	0.10	25	1.61	0.018	68
May 10, 1951	...	...	12	4.47	0.11	25	1.63	0.023	22
May 24, 1951	1.56	0.05	33	4.55	0.09	33	1.63	0.020	31
June 7, 1951	1.81	0.05	42	4.59	0.13	35	1.66	0.026	43
June 21, 1951	2.00	0.05	63	5.06	0.09	29	1.63	0.019	46
July 26, 1951	2.61	0.05	49	5.26	0.09	39	1.63	0.022	40
August 23, 1951	2.87	0.05	61	5.26	0.11	30	1.68	0.025	37
September 26, 1951	3.30	0.05	68	5.48	0.10	37	1.56	0.027	43
October 25, 1951	3.40	0.08	41	5.89	0.14	36	1.64	0.021	45
November 29, 1951	3.30	0.06	51	5.60	0.11	30	1.47	0.021	32
January 2, 1952	3.35	0.08	44	5.72	0.09	36	1.34	0.015	45
February 1, 1952	3.44	0.08	53	5.76	0.08	30	1.39	0.013	46
March 4, 1952	3.43	0.08	49	5.91	0.11	37	*1.41	0.012	59
October 25, 1951 to March 4, 1952, inclusive	3.41	0.034	238	5.78	0.048	169	...	...	...
Pigeon River									
March 27, 1951	...	...	0	4.22	0.09	51	1.31	0.026	28
April 12, 1951	...	...	0	4.19	0.08	71	1.45	0.020	37
April 27, 1951	...	...	24	4.24	0.08	66	1.50	0.024	29
May 11, 1951	...	...	12	5.05	0.09	42	1.74	0.016	37
May 25, 1951	1.57	0.05	28	5.21	0.11	38	1.67	0.019	46
June 8, 1951	1.94	0.04	34	5.76	0.10	37	1.64	0.019	46
June 22, 1951	2.18	0.07	45	5.71	0.11	40	1.62	0.016	45
July 27, 1951	2.93	0.08	44	5.81	0.13	33	1.65	0.020	36
August 25, 1951	3.48	0.06	56	6.08	0.11	41	1.55	0.018	48
September 27, 1951	3.67	0.06	53	6.13	0.09	48	1.47	0.015	53
October 26, 1951	3.84	0.06	60	6.47	0.15	29	1.50	0.022	36
November 30, 1951	3.74	0.08	51	6.33	0.12	41	1.42	0.020	44
January 3, 1952	3.84	0.07	53	6.08	0.07	42	1.32	0.015	46
February 4, 1952	3.88	0.07	54	5.97	0.11	25	1.27	0.015	27
March 5, 1952	4.01	0.06	68	6.39	0.12	38	1.27	0.012	48
October 26, 1951 to March 5, 1952, inclusive	3.87	0.030	286	6.26	0.053	175	...	...	...
North Branch of Au Sable									
March 29, 1951	...	...	0	4.52	0.09	70	1.42	0.019	27
April 11, 1951	...	...	71	4.51	0.07	138	1.55	0.019	40
April 26, 1951	...	...	50	4.81	0.08	107	1.55	0.016	53
May 10, 1951	...	...	20	5.53	0.14	38	1.75	0.021	46
May 24, 1951	1.54	0.06	25	6.19	0.14	29	1.81	0.022	45
June 7, 1951	1.97	0.07	35	6.49	0.12	42	1.91	0.016	56
June 21, 1951	2.30	0.08	43	6.87	0.11	42	1.82	0.019	56
July 26, 1951	2.77	0.07	45	7.28	0.13	29	1.76	0.017	49
August 23, 1951	3.50	0.07	43	7.19	0.12	38	1.71	0.018	46
September 26, 1951	3.75	0.09	50	7.77	0.11	29	1.65	0.020	43
October 25, 1951	3.48	0.11	76	8.36	0.11	36	1.73	0.019	47
November 29, 1951	4.42	0.11	69	7.21	0.14	33	1.46	0.024	44
January 2, 1952	4.22	0.10	69	7.94	0.13	34	1.43	0.018	50
February 1, 1952	4.64	0.10	57	7.86	0.11	41	1.38	0.014	50
March 4, 1952	4.15	0.11	66	7.92	0.15	45	1.42	0.014	53
October 25, 1951 to March 4, 1952, inclusive	4.15	.0.053	337	7.87	0.063	189	...	...	...

* Collection date, March 11, 1952.

summer and some during their second summer. In the North Branch of the Au Sable where growth is rapid, under a 7-inch minimum size limit, about half of the brook trout would be legal targets for fishermen by July 1 of their second summer.

CHANGE IN CONDITION.—The coefficient of condition (R) has been used to determine changes in relative weight throughout the year (Cooper and Benson, 1951). Fish under 5.0 inches total length have not been used in these comparisons because the balances used were not accurate enough under field conditions to record minor differences in weight. Also, the unit of measurement of weight used (one gram) represents too large a proportion of the total weight of small fish to detect minor changes in condition. The coefficient of condition was computed for each fish in a sample and their average condition obtained from these computations.

The condition of the brook trout was uniformly low in all three streams during late March and early April, 1951. It rose rapidly during late April and May, reached a peak usually about the first week in June, and declined thereafter to the winter low condition. There was a decided drop in condition during October and November which was probably associated with spawning. The condition of the brook trout in the North Branch of the Au Sable River rose to a much higher peak in June than did that of the trout in Hunt Creek and the Pigeon River. Also, this high level of condition was maintained by the fish from the North Branch of the Au Sable over a much longer period during the summer (Fig. 1).

These average changes in condition from the winter low to early summer high represent tremendous differences in relative weight. In Hunt Creek, where the least amount of differences occurred, the fish gained an average of 22 percent of their winter weight during a period of two months in the spring, disregarding the additional weight accompanying the growth in length. For the Pigeon River and the North Branch of the Au Sable River these values were 33 percent and 35 percent, respectively.

An apparent correlation between high condition factor and growth is suggested by the data from these three streams. Growth rate increases rapidly in the spring, coincident with an increase in condition, and is maintained at a rapid rate only so long as the condition factor remains high. When the condition decreases in late summer, fall and winter, growth also decreases.

BOTTOM FAUNA.—The distribution and abundance of the invertebrate fauna were studied by a series of nine square-foot bottom samples from each of the three streams (Table II). This collecting was done in mid-February, just in advance of the trout growing season in 1952, using the sampler described by Surber (1937). The abundance of different bottom types (gravel, sand, and silt) in each stream section was estimated visually and samples were taken from these different bottom types in proportion to their abundance. Many samples were taken in sand, and mixtures of sand, in Hunt Creek because of the predominance of these bottom types in this stream. The series of samples from the North Branch of the Au Sable River averaged 2.87 cc. per square foot of bottom; the values for the Pigeon River and Hunt Creek were 2.26 cc. and 1.06 cc., respectively. Values of "t" (with eight degrees of freedom) for the differences of the means of these series of bottom samples are as follows:

North Branch of the Au Sable River and Hunt Creek.....2.99 (98% level)
Pigeon River and Hunt Creek.2.55 (96% level)
North Branch of the Au Sable River and Pigeon River.....0.88 (60% level)

Leonard (1939) has discussed in some detail the adequacy of this technique of bottom sampling and makes note of its many limitations in the determination of the food supply of fishes.

TABLE II

BOTTOM FAUNA IN NORTH BRANCH OF THE AU SABLE RIVER, PIGEON RIVER, AND HUNT CREEK, IN NINE SQUARE-FOOT SAMPLES FROM EACH STREAM

Type of Organism	N. Br. Au Sable February 14, 1952		Pigeon River February 6–11, 1952		Hunt Creek February 14, 1952	
	Number	Volume in c.c.	Number	Volume in c.c.	Number	Volume in c.c.
Ephemeroptera	2,058	13.700	564	6.000	410	3.150
Plecoptera	66	0.625	59	0.575	15	Trace
Trichoptera	480	4.750	1,748	8.325	345	1.800
Diptera	743	3.300	900	2.700	452	2.550
Others	241	3.425	310	2.775	256	2.050
Totals	3,588	25.800	3,581	20.375	1,478	9.550
Average per square foot	399	2.87	398	2.26	164	1.06

TABLE III

MEAN WEEKLY MAXIMUM TEMPERATURES FOR THE NORTH BRANCH OF THE AU SABLE RIVER (AT TWIN BRIDGES, 2 MILES NORTH OF LOVELLS), PIGEON RIVER (13 MILES EAST OF VANDERBILT), AND HUNT CREEK (10 MILES EAST OF LEWISTON)

Weekly period	Mean weekly maximum water temperature (°F.)		
	N. Br. Au Sable River	Pigeon River	Hunt Creek
March 3–9, 1951	...	36	39
March 10–16	...	37	38
March 17–23	...	36	37
March 24–30	...	36	38
March 31 – April 6	...	39	41
April 7–13	...	42	45
April 14–20	...	40	41
April 21–27	...	43	46
April 28 – May 4	59	57	60
May 5–11	51	56	55
May 12–18	61	60	60
May 19–25	64	63	63
May 26 – June 1	67	61	63
June 2–8	68	61	62
June 9–15	65	64	62
June 16–22	70	66	65
June 34–29	66	66	64
June 30 – July 6	66	65	64
July 7–13	63	66	66
July 14–20	70	69	65
July 21–27	69	70	67
July 28 – August 3	70	71	68
August 4–10	63	66	63
August 11–17	65	64	63
August 18–24	65	64	63
August 25–31	65	66	65
September 1–7	61	62	61
September 8–14	60	62	61
September 15–21	...	59	60
September 22–28	...	54	54
September 29 – October 5	...	54	56
October 6–12	...	50	52
October 13–19	...	53	54
October 20–26	...	48	51
October 27 – November 2	...	47	44
November 3–9	...	37	35
November 10–16	...	40	39
November 17–23	...	36	36
November 24–30	...	36	36
December 1–7	...	41	41
December 8–14	...	37	36
December 15–21	...	34	32
December 22–28	...	34	32
December 29 – January 4, 1952	...	35	34
January 5–11	...	35	34
January 12–18	...	36	36
January 19–25	...	34	32
January 26 – February 1	...	34	32
February 2–8	...	36	34
February 9–15	...	35	33
February 16–22	...	35	32
February 23–29	...	37	34
March 1–7	...	36	33
March 8–14, 1952	...	37	37

The present study was not intended to furnish detailed data but rather to indicate a possible avenue of investigation of the causes of the large differences in growth of the trout noted in these stream sections. The difference in abundance of bottom fauna noted in these stream sections is sufficient to indicate that the food supply is a contributing factor in the slow growth of the Hunt Creek population of brook trout. However, more detailed analysis of bottom fauna production on an area basis and better knowledge of the forage-ratios of particular groups of organisms present is needed for a proper evaluation of this environmental factor.

STREAM TEMPERATURES.—Some information on water temperatures is available from the three stream sections studied. On the Pigeon River, a thermograph located about two miles downstream from the sampling area has been in continuous operation. Water temperatures at the site of fish sampling have been within one or two degrees of agreement with thermograph readings.

A thermograph has also been in operation on Fuller Creek, a tributary of Hunt Creek and comparable water temperatures for the sampling area in Hunt Creek have been obtained by adjusting these thermograph records on a basis of numerous coincident temperatures at both stream sites.

For the North Branch of the Au Sable River, temperatures were taken 2 to 4 days of each week during the trout season with a pocket thermometer. The time of observation here

varied between 1:30 P.M. and 2:30 P.M. and attempts were made to record near-maximum water temperatures for the day. Temperature data from the North Branch of the Au Sable River are not considered as representative of true conditions as are those of Hunt Creek and the Pigeon River.

The mean maximum water temperature for each week has been computed from the daily records available (Table III). In all three streams, water temperatures warmed abruptly during the last week in April and the first week in May, coincident with the disappearance of the accumulation of winter snow. Although the summer of 1951 was somewhat cooler than average, many daily maximum water temperatures over 70° F. were recorded, especially in the North Branch of the Au Sable and the Pigeon rivers. Daily temperatures over 60° F. were the rule during the months of May through September. During December, January, February and March, maximum water temperatures were seldom above 36° F.

DISCUSSION.—The data presented earlier concerning the rapid growth in the spring and the high condition factor of the brook trout at this time suggest a relationship between the two. This relationship was also found to hold for brown trout studied under controlled laboratory conditions, according to Brown (1946a: 142): "Growth in length, which involves retional differentiation, occurs at a rate directly proportional to the condition factor and thus to the amount of reserve food."

Hansen (1951) also observed that in white crappies high condition accompanied rapid growth and that increases in K values occurred only during the annual growing period.

Stroud (1949), reporting on the growth of game and pan fishes in Tennessee, stated that values of K were found to vary from one reservoir to another in about the same manner as the growth rates of each species varied, averaging highest for fastest growing populations and lowest for slowest growing populations. However, in the same study he stated that K is low immediately following spawning, although it may be even lower in late summer after periods of extremely rapid growth, and that fishes of Norris Reservoir fatten up during fall and winter without increasing in length.

In a review of some environmental relations of the speckled trout, Fry (1951) listed temperature as one of the most decisive factors in determining the success of the brook trout in streams. Much interest has centered around optimum temperature conditions for growth, and some experimental work has been reported. Brown (1946b), reporting on the growth of brown trout, found that the specific growth rates of trout living at different constant temperatures and of those living in water of changing temperature were high between 7° and 9° C. (45° and 48° F.) and between 16° and 19° C. (61° and 66° F.), and were low above, between and below these temperatures. Baldwin, 1951, (quoted from Fry, 1951) measured the growth rate of a series of 4 brook trout allowed to take minnows at will in a confined space. Optimum growth under these circumstances took place at approximately 14° C. (57° F.). Davis (1946) also stated from fish culture experience that the optimum for growth of trout appears to lie between 55° and 60° F.

These temperature data on optima for growth agree with field observations in the present study. A change in maximum temperatures from 40° to 50° F. during April, to 50° to 65° F. during May and June, is accompanied by a tremendous increase in condition and growth. This was noted in all three streams studied. However, water temperatures fail to explain the differences in growth noted between Hunt Creek and the North Branch of the Au Sable River, for temperature conditions in Hunt Creek remain within the optimum range throughout the summer and fall while those in the North Branch of the Au Sable River frequently go over 70° F. The much higher level of condition reached by the trout in the North Branch of the Au Sable River compared with Hunt Creek during the month of May, when temperature conditions were very similar, also suggests that the abundance of natural food in the North Branch of the Au Sable River is an important factor in the difference in growth of the trout populations in these streams.

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and Dr. G. P. Cooper critically reviewed the manuscript.

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Ichthyological Notes

OCCURRENCE OF AN OIL GLOBULE IN EGGS OF PLEURONECTID FLATFISHES.[1]—In the literature on eggs of flatfishes it is commonly stated that an oil globule is present in the family Bothidae and absent in the family Pleuronectidae. This character was included by Norman (1934, Monograph of Flatfishes, vol. 1) both in the diagnoses and in the general discussion of these two families, and has been cited and used variously by subsequent authors, including Orcutt (1950, Calif. Div. Fish and Game, Fish Bull. No. 78).

Several apparent exceptions to this pleuronectid egg characterization have long been carried in the literature. From work by Anderton (1907, Trans. Proc. New Zealand Inst., 39: 477–95) and Thomson and Anderton (1921, Bull. New Zealand Bd. Sci. Art, 2: 9–131) it was known that from one to several oil globules occur in the eggs of six flatfishes of the *Rhombosolea* group, which was treated by Norman as a subfamily of the Pleuronectidae. Chabanaud (1946, Bull. Mus. Nat. Hist. Paris, (2) 18: 160) has recently elevated the group to family rank. In addition to adult characters, he emphasized the presence of oil globules in eggs of rhombosoleids and their absence in eggs of pleuronectids, *sensu restricto* (1949, Bull. Mus. Nat. Hist. Paris, (2) 21: 673–75).

In a typical pleuronectid, *Pseudopleuronectes americanus* (Walbaum), it was reported by Breder (1922, Bull. U. S. Bur. Fish., 38: 311–15) that freshly spawned eggs lack an oil globule but that many of the embryos develop a transitory structure resembling it. This was interpreted as the definite occurrence of an oil globule in this species by Bigelow and Welsh (1925, Fishes of Gulf of Maine, p. 505) and by Norman (*op. cit.*, p. 30). From Breder's original description and figures, however, it can be seen clearly that the structure in question is actually the Kupffer's vesicle, a transitory organ of normal occurrence in teleost embryos. The egg of *Pseudopleuronectes americanus* thus agrees with other described pleuronectid eggs in lacking an oil globule.

The character of absence of an oil globule in pleuronectid eggs is so well entrenched in the literature that it is of interest to report that certainly one, and probably two, exceptions to it have been found among the pleuronectid flatfishes of California. On two occasions the junior author has obtained eggs of *Hypsopsetta guttulata* (Girard) by stripping ripe adults collected off Scripps Institution, and eggs with the same structure and developing the same easily-recognized embryonic and prolarval characters have occurred repeatedly in plankton samples taken off Scripps Institution during the summer of 1952. All of the eggs of this flatfish that

[1] Contributions from the Scripps Institution of Oceanography, New Series, No. 607.

we have seen contain a conspicuous, typical, moderately large oil globule. The egg capsule is simple, without polygonal sculpturing or other apparent texture.

The same plankton samples have occasionally included another type of flatfish egg, with an oil globule, that is possibly a pleuronectid but is not yet certainly identified. The capsule of this type of egg has the conspicuous polygonal sculpturing described by Budd (1940, Calif. Div. Fish and Game, Fish Bull. No. 56) in three of the four California species of the pleuronectid genus *Pleuronichthys*. In size, general appearance, and developmental characteristics this egg and its resulting prolarva closely resemble Budd's description and figures of *Pleuronichthys verticalis* (Jordan and Gilbert), but differ consistently in possessing a small oil globule, in color (light pigment cells brownish-orange instead of yellow), and in pattern and mode of its formation, especially on the median finfolds. Eggs and prolarvae essentially agreeing with Budd's *P. verticalis* have also been taken at La Jolla. The form with the oil globule may be *Pleuronichthys ritteri* (Starks and Morris), the only local member of the genus with eggs still undescribed, but there is also a possibility that it may represent some other pleuronectid genus. Among flatfishes, eggs with polygonal sculpturing on the capsule have apparently been reported only in *Pleuronichthys*, but this type of egg modification is also known to occur in such widely divergent families as the Macrouridae and the Callionymidae.

Hypsopsetta and *Pleuronichthys* are regarded as closely related and relatively primitive pleuronectid genera. It is possible that an oil globule was primitively present in pleuronectid eggs and has been lost subsequently in most of the extant evolutionary lines in the family. The Pleuronectidae and Bothidae are thought to be closely related and of common origin (Hubbs, 1945, Misc. Publ. Mus. Zool. Univ. Mich., No. 63). The occurrence of oil globules is of such random nature in teleosts in general that its taxonomic value is usually limited to the lower categories. On present knowledge, the oil globule itself cannot be said to be either primitive or advanced.—GRACE L. ORTON AND CONRAD LIMBAUGH, *Scripps Institution of Oceanography, University of California, La Jolla, California.*

YELLOW BULLHEAD PREYED UPON BY COTTONMOUTH MOCCASIN.—Catfishes are frequently cited as examples of vertebrates which possess a remarkable defensive mechanism in the form of spines and poison glands. In spite of this protection, they are known to be only partially immune to predation, and many fishermen will attest to the effectiveness of the small madtoms as bait for black bass. Adams and Hankinson (1928, Roosevelt Wild Life Annals, 1: 235–548) mentioned a number of incidents in which catfishes had been consumed by black bass, sand pike, yellow bullheads, mud cats, snapping turtles, and water snakes, and attacked by lampreys. Allen and Swindell (1948, Herpetologica, 4: 1st suppl.) reported that catfishes were included in the frog and fish diet of the cottonmouth moccasin. In some individuals the spines had caused injury and death to the snake; in others, they became lodged in the neck, the remainder of the fish was digested, and the wounds healed around the protruding spines. These accounts made no mention of the size of the catfishes eaten by the various predators, but it may be assumed that the fishes were generally small. The following observation indicates that large bullheads occasionally become prey for other animals.

On October 26, 1951, Messrs. Archibald Sharer and Everett A. Kelly (both of Florida State University) killed a moccasin, *Agkistrodon piscivorus* (Lacépède), at MacBride's Slough, 2.6 miles WNW of Wakulla, Wakulla Co., Fla. This snake was 63 inches long and had a large bulge near the middle of its body. Dissection revealed an adult yellow bullhead, *Ameiurus natalis* (LeSueur), which had been swallowed head first by the snake. The anterior third of the body was partially digested, but the posterior portion was undamaged. Specific identification was readily made by means of the anal ray count (26), the rounded tail, and the uniform coloration. The bullhead was 306 mm. (nearly 12 inches) in standard length, and on the basis of other published data (Carlander, 1950, Handbook of Freshwater Fishery Biology, Dubuque, Iowa) probably weighed about one and one-half pounds. The weight of the moccasin was estimated to be approximately seven pounds. The large size of both predator and prey is unusual in this part of the country. —RALPH W. YERGER, *Department of Zoology, Florida State University, Tallahassee, Florida.*

SCHOOLING OF THE ORANGE FILEFISH, *ALUTERA SCHOEPFI*, IN NEW YORK BIGHT.—A school of 8 orange filefish, *Alutera schoepfi* (Walbaum), was sighted and observed drifting at the surface on August 15, 1952, when our vessel was hove to approximately 12 miles offshore at 40° 23′ N lat., 73° 40′ W long. These fish were estimated to range in size from 8 to 10 inches in total length. The depth of the water was just over 13 fathoms (about 80 feet), and the bottom consisted of sand and shell. No floating seaweed was present in the immediate area. The water temperature was not determined. The sea was very calm and conditions for observation were ideal.

A. schoepfi is usually recorded along sandy shores

and in bays and inlets, especially near eel grass (Bean, 1903, Fishes of New York: 614–15; and Breder and Nichols, 1927, The Marine Fishes of New York and Southern New England: 137). According to Longley and Hildebrand (1941, Systematic Catalogue of the Fishes of Tortugas, Florida: 291–92), large specimens were occasionally taken in 10 to 14 fathoms of water. It was further stated that the filefish were taken or sighted "within and without the lagoon" but no indication was given regarding how far offshore they were seen. These authors, as well as Breder (1948, Field Book of Marine Fishes of the Atlantic Coast: 227), stated that the young are often found in *Sargassum*, although it was not indicated if the weed was found in the open sea or washed close into shore. A further search of the literature revealed no records of pelagic existence and schooling behavior of the orange filefish.

The school observed by us assumed an almost stationary position with the fish's bodies inclined so that their heads were pointed downwards with the tails near the surface (as described by Longley and Hildebrand). They drifted along very slowly and seemed to make no effort to move, but rather adopted an almost planktonic existence. This drifting behavior was described in a somewhat similar manner for an individual fish by Longley and Hildebrand.

A further interesting behavior pattern was seen when the filefish formed a rosette-like pattern with the heads of each fish pointed towards a common central point. In this position the school resembled an arrangement of floating portions of seaweed. The bodies of each of the filefish imitated a frond or thallus body. Breder (1946, Bull. Bing. Ocean. Coll., 10 (2): 18–19) has mentioned the resemblance of a single filefish to a leaf. Possibly this species is overlooked even further out to sea because of the marked resemblance to plant parts.—Ronald W. Crawford and Charles F. Powers, *Department of Conservation, Cornell University, Ithaca, New York.*

OCCURRENCE OF THE MOUNTAIN-SUCKER, *PANTOSTEUS JORDANI*, IN THE WILLAMETTE RIVER SYSTEM, OREGON.—A single specimen of the mountain-sucker, *Pantosteus jordani* Evermann, 97 mm. in standard length, was discovered in a collection of fishes made by Richard E. Noble and Gene Deschamps in a diversion ditch off the South Santiam River at Lebanon, Oregon, on May 4, 1951. Oregon locality records for the species had previously been confined to streams east of the Cascade Mountains; Schultz and DeLacy (1935, Jour. Pan. Pac. Res. Inst., 10 (4): 376) listed it from the Snake River, John Day River, Wallowa Lake and Umatilla River.

In order to verify the record and identification, a collection was made at Lebanon Dam, 3 miles above Lebanon, on June 21, 1951, by Carl E. Bond and Richard E. Noble. Thirty-nine additional specimens (103 mm. to 141 mm. long) were taken in turbulent water on the apron of the dam along with *Prosopium oregonium* (Jordan and Snyder), *Ptychocheilus oregonense* (Richardson) and *Richardsonius balteatus balteatus* (Richardson). One female was noted with mature ova. The water temperature was 72°F.

A search of unidentified specimens in the Oregon State College Department of Fish and Game Management instructional collection disclosed 11 *Pantosteus jordani* (16.5 mm. to 31.5 mm. long), from Eula, on the Middle Fork of the Willamette River, taken in August, 1944, by R. E. Dimick. Three specimens (42 mm., 48 mm., and 54 mm. long) were found in a collection made by Dan Dion in the Middle Fork of the Willamette River on April 13, 1949.

Additional collecting during the summers of 1951 and 1952 has shown the mountain-sucker to be fairly abundant in the Willamette River system. This species has now been obtained at the following collecting stations in addition to those listed above: Willamette River at Eugene, three miles below Eugene, Corvallis, Albany, Independence, Wheatland Ferry, at the mouth of the Clackamas River below Oregon City, South Fork of the Santiam River at Crabtree Bridge, and in the Clackamas River at Gladstone. The mountain-sucker was not listed by Jordan (1878, Proc. U. S. Nat. Mus., 1: 69) for the Clackamas River or by Snyder (1908, Bull. U. S. Bur. Fish., 27 (1907): 157–59) as present in the Willamette drainage. The scarcity of the species in 1943 and 1944, when extensive collecting was carried out on the Willamette River, and its abundance at the present time, might indicate that *Pantosteus* is a recent invader of the Willamette system.—Carl E. Bond, *Department of Fish and Game Management, Oregon State College, Corvallis, Oregon.*

A XANTHIC LARGEMOUTH BASS (*MICROPTERUS*) FROM FLORIDA.—A xanthic Florida largemouth bass, *Micropterus salmoides floridanus* (LeSueur), was taken in December, 1949, at Nelson's Fish Camp on the Oklawaha River, near Starke's Ferry, Marion County, Florida. It was a large female, 22½ inches in standard length, weighing 10 pounds 4 ounces. The color was bright golden yellow above, fading to pure white on the belly and lower jaw. Small grayish flecks formed lines on the first eight scale rows (counted downward from the dorsal fin). These were the only dark markings on the body. The dorsal, anal, and pectoral fins were

immaculate lemon yellow, the pelvic fins lemon yellow with black tips. The caudal fin was a dark yellow, with reddish smudges and a few black vermiculations. The iris of the eye was golden. There was no trace of an opercular dark spot or of postocular dark stripes. This brilliant yellow fish must have been very conspicuous in the Oklawaha River, a "black water" stream. Nevertheless, it was plump and apparently in excellent condition. The specimen was mounted and is in the senior author's possession.—E. Ross Allen and Wilfred T. Neill, *The Reptile Institute, Silver Springs, Florida.*

RECORD OF THE FISH *CHIMAERA MONSTROSA* FROM PUERTO RICO.—In the evening of February 27, 1951, a rare specimen of fish was brought to Professor J. A. Ramos, Chairman of the Department of Biology of the College of Agriculture of the University of Puerto Rico at Mayaguez, Puerto Rico. The specimen was easily placed in the genus *Chimaera*, of the holocephalian elasmobranchs. It was caught by a local fisherman on hook and line with squid for bait, off Punta Higuero, west coast of Puerto Rico (18° 25′ N. lat., 67° 10′ W. long.) According to the fisherman the collection was made at a depth of approximately 200 fathoms. On June 28, 1951, Dr. Luis René Rivas, while in Puerto Rico as Visiting Professor at the University of Puerto Rico, identified the rare specimen as *C. monstrosa* Linnaeus. This is the first record of this fish from the waters of Puerto Rico, although it was recorded by Poey from Matanzas, Cuba (1868, Synopsis, Repertorio, ?: 445). The animal is a male in perfect condition, and is deposited in the fish collection of the Department of Biology of the College of Agriculture and Mechanic Arts of the University of Puerto Rico.—Virgilio Biaggi, Jr., and Pedro Jaime Soler, *Department of Biology, College of Agriculture and Mechanic Arts, Mayaguez, Puerto Rico.*

ECOLOGY, AGE AND GROWTH OF THE MUD SUNFISH, *ACANTHARCHUS POMOTIS*, IN MARYLAND.—The mud sunfish, *Acantharchus pomotis* (Baird), is a little-known, secretive centrarchid found in lowland streams and sluggish waters of the Atlantic Coastal Plain from southeastern New York to northern Florida (Florida specimens at the University of Michigan). During a fishery survey of Chamber's Lake at Federalsburg, Caroline County, Maryland, 14 specimens of this species were collected on October 26, 1950. This represents the first definite record of *Acantharchus* in the State, although Cope (1873, Walling and Gray's New Topogr. Atlas of Md., p. 17) alluded to its occurrence as follows: "... the mud sunfish (*Ambloplites pomotis*, Baird), which grows to the size of a white bass in the sluggish streams of the tide-water region, will become at some future day a source of food to a considerable population." He implied that this species, with other centrarchids, could be propagated in large numbers for commercial sale. Subsequent important studies of Maryland's fish fauna, as summarized by Truitt, Bean and Fowler (1929, Conserv. Bull. 1, Md. State Conserv. Dept., 1–120) did not reveal its occurrence there.

A clue to its apparent scarcity is given by Breder (1936, Zoologica, 21 (1): 34) who quoted Abbott's observations concerning the nocturnal habits of the species. Breder also pointed out that this species is "much more secretive than other members of the family...." Residents of the Federalsburg region who had fished in the pond during their lifetime did not recognize the fish, nor did they have a name for it.

Chamber's Lake is a typical millpond of the Coastal Plain of Maryland. The entire region consists of low, flat, agricultural land except for some marshes and swamps, and is drained by numerous, sluggish small streams. The millpond was originally constructed for the production of power to process grain and lumber during the eighteenth and nineteenth centuries. At present, the pond is used for swimming, boating and fishing.

The importance of this pond for largemouth bass fishing necessitated, in 1950, the attempted removal of all fish for management purposes. Emulsifiable rotenone was used after drawing down the pond to concentrate the fish in a small area. This chemical did not seem to be so effective in drugging the mud sunfish as it was for the other species. Large numbers of all other species enumerated below were asphyxiated, but only a few *Acantharchus* succumbed immediately to the effects of the drug. Perhaps their predilection for cavities, underwater furrows, or labyrinths formed by the root stocks of aquatic plants provided them with a method for escaping the penetrating rotenone. A number of specimens were found slowly meandering downstream above the pond proper; however, when handled they thrashed about wildly and darted swiftly, partially burying the pelvic and anal fins in the mud. In most instances, they sought refuge beneath banks and shaded portions of the stream. Despite the effort to eliminate a large percentage of the fish species from the pond, it is conceivable that numbers of mud sunfish, more so than any other species, escaped notice. None was observed to head upstream away from the rotenoning operation

A general analysis of the biological, physical and chemical data taken at Chamber's Lake in August, 1950, indicated that the productivity of the pond was high. Aquatic vegetation consisted of *Sparganium, Typha, Nymphaea advena, Brasenia schreberi,*

Anacharis canadensis, and *Vallisneria spiralis*. The abundance of these plants and much algae, in association with an abundant aquatic fauna, was such that good growth could be expected. The water was turbid, slightly brown, and filled with suspended matter. The dissolved oxygen concentration was normal for good productivity, while the hydrogen ion concentration (pH) was neutral on the surface and slightly acidic below (Table I).

TABLE I

PHYSICAL AND CHEMICAL DATA FROM CHAMBER'S LAKE, MARYLAND, AUGUST 16, 1950

Analyses	Water depth	
	Surface	6 feet
Temperature, degrees F	74	72
Dissolved oxygen, ppm	8.9	9.7
Carbon dioxide, ppm	10	12
Phenolphthalein alkalinity, ppm	0	0
Methyl Orange alkalinity, ppm	10	10
Total alkalinity, ppm	10	10
pH	7.0	6.8
Secchi disk reading, in feet	4.5	

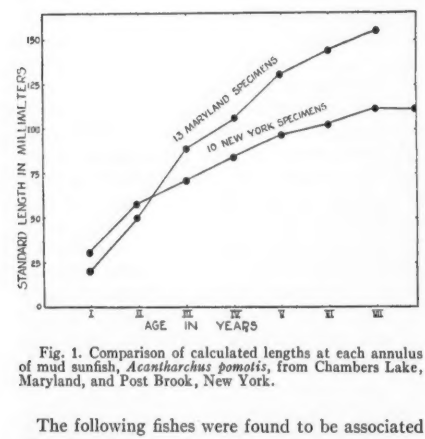

Fig. 1. Comparison of calculated lengths at each annulus of mud sunfish, *Acantharchus pomotis*, from Chambers Lake, Maryland, and Post Brook, New York.

The following fishes were found to be associated with *Acantharchus: Lampetra aepyptera, Erimyzon o. oblongus, Notemigonus c. crysoleucas, Ameiurus natalis erebennus, A. n. nebulosus, Schilbeodes mollis, Esox niger, E. americanus, Umbra pygmaea, Anguilla rostrata, Aphredoderus s. sayanus, Hololepis fusiformis erochrous, Micropterus s. salmoides, Lepomis auritus, L. gibbosus, L. m. macrochirus, Enneacanthus gloriosus*, and *Pomoxis nigromaculatus*. The largemouth bass, bluegill, and black crappie have been introduced.

The secretive nature of the fish, its apparent rarity, and the dearth of published information on the mud sunfish have prompted us to present data on its growth. Carlander (1950, Handbook of Freshwater Fish. Biol., pp. 2–3) has aptly pointed out that, "A sample of five or ten fishes may give an erroneous picture of the growth or length-weight relationships in a body of water." Hence, it is easy to see why discrepancies exist in the comparison between the lengths given by Breder and Redmond

TABLE II

STANDARD LENGTHS AND WEIGHTS OF 14 SPECIMENS OF THE MUD SUNFISH, *Acantharchus pomotis*, FROM CHAMBER'S LAKE, MARYLAND, OCTOBER 26, 1950

Specimen number	Standard length, millimeters	Weight, grams
1	111	48
2	114	68
3	118	71
4	119	65
5	119	74
6	123	78
7	123	78
8	124	78
9	126	91
10	149	142
11	151	142
12	158	139
13	162	156
14	170	190

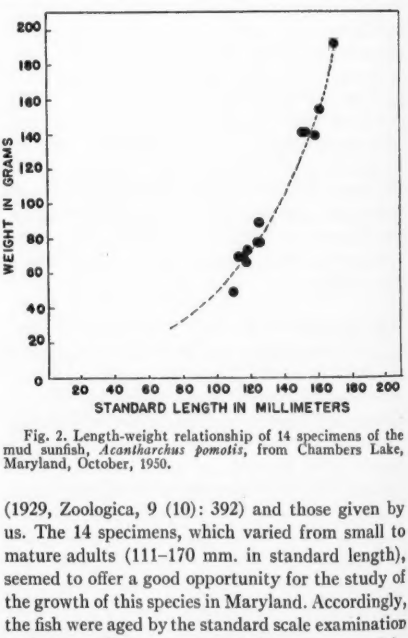

Fig. 2. Length-weight relationship of 14 specimens of the mud sunfish, *Acantharchus pomotis*, from Chambers Lake, Maryland, October, 1950.

(1929, Zoologica, 9 (10): 392) and those given by us. The 14 specimens, which varied from small to mature adults (111–170 mm. in standard length), seemed to offer a good opportunity for the study of the growth of this species in Maryland. Accordingly, the fish were aged by the standard scale examination technique. Their ages varied from two to eight summers, and their growth apparently proceeded at a normal rate (Fig. 1). The greatest rate of growth

was generally observed in the third summer. The calculated lengths of these fish, when compared with those from Post Brook, New York (Breder and Redmond, *op. cit.*). show that the Maryland specimens grew at an appreciably faster rate. This may be due to a difference in length of growing season, as the habitats and ecological conditions are probably similar.

The Maryland growth rates are only tentative, inasmuch as the sample of *Acantharchus* is small. This may be the reason for the rather high conversion factor (1.281) which was computed from Maryland specimens for changing standard to total length. The total length can be converted to standard length with the factor 0.783. Figure 2 shows the length-weight relationship of the 14 specimens based on the data in Table II; a gap in the curve results from the lack of specimens between 128 and 148 mm. in length. The homocercal tail of the mud sunfish precludes the need for a conversion factor for standard to fork-length. The inadequacy of the sample prevented any significance to be attached to the sex ratio in relation to growth.

Sincere appreciation is expressed to Dr. R. V. Truitt, director, and Mr. R. D. Van Deusen, biologist, Maryland Department of Research and Education, Solomons, Maryland, for reviewing the manuscript.—ROMEO MANSUETI AND HAROLD J. ELSER, *Maryland Department of Research and Education, Solomons, Maryland.*

Herpetological Notes

NOTES ON THE SALAMANDER *SIREN INTERMEDIA*.—In connection with a demonstration of the use of rotenone as a fish poison in a farm pond, we found that, in addition to killing the fish, the poison killed or otherwise incapacitated large numbers of sirens. Since little information on the biology of this animal is available in the literature, this seemed a desirable opportunity to collect a large number of animals from one pond to study sex ratios, breeding conditions, age classes, and food habits.

The pond from which the specimens were obtained is situated on the property of Mr. E. R. Alexander, 2.5 miles northeast of College Station, Brazos County, Texas. It was 2.4 acres in surface area with an average depth of 4.7 feet at the time of poisoning. The rotenone was applied at the rate of 2 pounds per acre-foot at 2:15 PM, April 24, 1951, and was thoroughly mixed throughout the pond with an outboard motor on a boat.

Fish began dying almost immediately, and by 6:00 PM all scale fish were dead. The only remaining fish, the black bullhead (*Ameiurus melas*), showed signs of discomfort. No sirens were noticed at this time, although they were searched for diligently. The pond was checked again at approximately 8:00 PM, just before dark, but only a few bullheads were recorded. However, on the following morning, April 25, at 8:00 AM, many sirens were observed floating in the shallow water among the weeds at the margin of the pond. They were not dead but appeared to be in a semi-stupor for they did not move until touched, at which time they showed great alacrity in escaping from the dip net. The next morning a number of dead ones were found floating in the water or stranded on the shoreline. One specimen was on land at least 20 feet from the water's edge.

The lapse of time between the application of rotenone and the appearance of the sirens suggests that they were lying in the mud at the bottom of the pond during the day and so were protected from the rotenone, but on coming out during the night they exposed themselves to the poisoned water. The poorly developed eyes of sirens, indicating that they are night feeders, also supports this view.

A total of 209 specimens, ranging in size from 129 to 465 mm. in total length, were caught. Unfortunately, during the summer the fluid on some of the specimens evaporated and nearly a hundred specimens became so desiccated that they were worthless. The remaining 116 specimens were available for study.

The specimens were weighed, measured and then fixed in a straight position in an open pan in 2 percent formalin. Each specimen was tagged so it could be recognized. The sex and food habits were studied by autopsy, with the aid of a dissecting microscope.

REPRODUCTION.—All females 150 mm. or less in snout-vent length (Fig. 1) were sexually immature, the ovaries containing numerous white developing ova less than 1 mm. in diameter. In the smallest female examined (snout-vent length 88 mm.) the ovaries were as well developed as in those that measured 141–150 mm. All of these sexually immature females probably were yearlings, hatched the previous spring. Sexual maturity, seemingly, is not attained until the second year.

All females 151 mm. or more in snout-vent length

were either gravid, with large yolked, pigmented eggs nearly ready for deposition, or were approaching the gravid stage, with the eggs smaller but definitely pigmented at one pole. The condition of the ovaries of one large female suggested that she had oviposited recently. If so, the onset of the breeding season in this region is the latter part of April, but the peak probably is not reached until mid-May. Noble and Marshall (1932, American Mus. Novitates, 532: 1–17) reported finding eggs of *Siren intermedia* far advanced in development on April 8 and 10 near Imboden, Arkansas.

The sexually mature males were difficult to determine among our specimens, but in all males with a snout–vent length less than 190 mm. the gonads

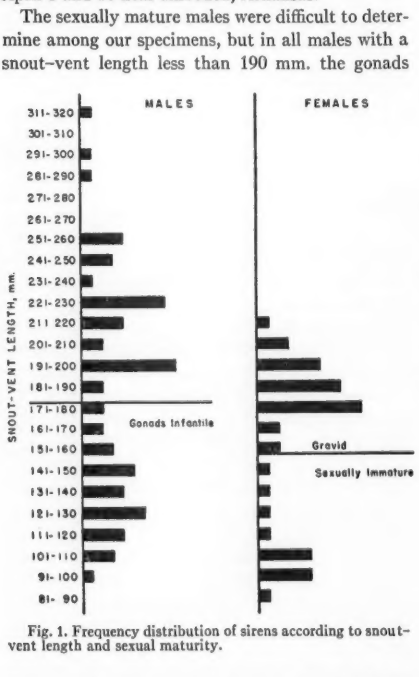

Fig. 1. Frequency distribution of sirens according to snout–vent length and sexual maturity.

were small and appeared inactive. In the larger males, the gonads appeared proportionately larger, especially in the three largest ones.

Growth.—The growth curve of this population was determined by plotting the snout–vent length against the weight of the animals (Fig. 2). In females, the largest size attained in this sample was a snout–vent length of 215 mm. (321 mm. total length) and a weight of 76 g. This is slightly less than the average for adult males and much less than the largest male which measured 313 mm. in snout–vent length (465 mm. total length) and weighed 265.4 g. Males not only appear to grow to a larger size, but they grow at a faster rate, at least during the period of sexual immaturity.

Bishop (1943, Handbook of Salamanders) reported that newly hatched sirens measure about 13 mm. in total length, the tail comprising only 2.5 mm. (snout–vent length, 10.5 mm.). Assuming that our specimens were of similar size when hatched, the average increment in snout–vent length during the first year in females was about 100 mm., or nearly ten fold. In males, this increment was about 130 mm.

Assuming that all of our gravid females were two-year-olds, except possibly for the largest ones, the average increase in snout–vent length during the second year was about 75 mm.; in males, the increase

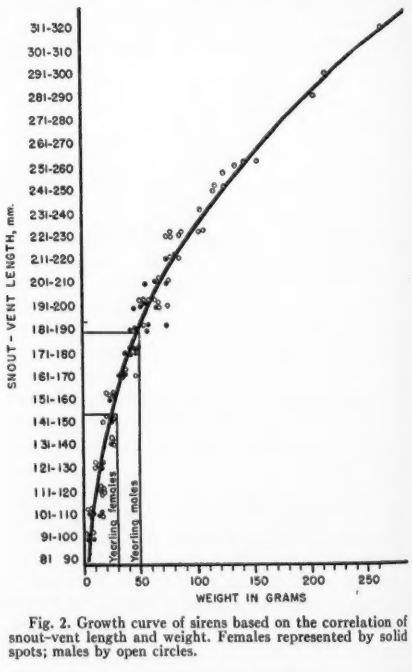

Fig. 2. Growth curve of sirens based on the correlation of snout–vent length and weight. Females represented by solid spots; males by open circles.

in the second year was about 90 mm. Our three largest males probably were three years of age or older. Until tagging studies are made, it seems unlikely that age classes in this animal can be determined with any degree of accuracy.

Food.—Thirty of the 116 specimens contained food remnants in the small and/or large intestine. The stomach in all specimens was empty, possibly because the effects of the rotenone prevented them from feeding.

Twenty-five (83.3 percent) of the animals had consumed large quantities of vegetation, chiefly filamentous algae and submerged plants resembling water milfoil (*Myriophyllum*), as well as bits of debris.

Midge larvae (*Chironomidae*) occurred in 16 (53.3 percent), with as many as a dozen individuals in one animal. The soft flocculent tubes of silt on the bottom of the pond in which these larvae live probably account for most, if not all, of the "mud" found in all the intestines that contained larval midges.

Larval mayfly (*Baetidae*) remains occurred in 13 (43.3 percent) specimens. These larvae, too, are bottom dwellers.

Other animal items include two water mites, bits of the shells of two small snails, and four cases of caddis fly pupae.

These data suggest that *Siren intermedia* is a bottom feeder, ingesting both living and dead vegetation and with it the associated invertebrates. The poorly developed eyes of *Siren* seem to support such a conclusion because their efficiency is doubtless insufficient to permit active pursuit of larger animals, especially in turbid water.

Our findings do not support Dunn's supposition (1924, Science, 49 (1519): 145) that *Siren* is mainly herbivorous. Not only were the invertebrates listed above eaten, sometimes in quantity, but also a good deal of the vegetable matter appeared to be undigested. Masses of filamentous algae in the colon were dark green in appearance and individual filaments were green and appeared to have been unaffected by the digestive fluids.

PARASITES.—Seven animals contained from one to three tapeworms in the small intestine, but they were so poorly preserved that their identification is difficult.

VARIATION IN NUMBER OF COSTAL GROOVES.—Since the number of costal grooves appears to be one of the chief diagnostic differences for separating the two subspecies of *Siren intermedia*, an effort was made to determine the individual variation of this character in this population sample. In *S. i. intermedia*, the usual number of grooves is 33 (31–34); in *S. i. nettingi*, 35 (34–36), according to Bishop (*op. cit.*). Counting the last groove reached by the adpressed leg as number three and considering the groove just anterior to the vent as the last in the series, the number in our 69 males varied as follows: 32–1; 33–29; 34–33; 35–5; 36–1. In 47 females the variation frequency was 32–6; 33–15; 34–23; 35–3. In both sexes the most common numbers of costal grooves were 33 and 34.

It is possible that our method of counting the grooves differed from that employed by Bishop. If the last groove reached by the adpressed limb is actually number four, our data would be in agreement with his and definitely place our specimens in the subspecies *S. i. nettingi*. Some standard should be adopted in counting the costal grooves in this species. We recommend adoption of the one used in this report.—WILLIAM B. DAVIS AND FRANK T. KNAPP, *Department of Wildlife Management, Texas A. and M. College, College Station, Texas.*

REPTILES AND AMPHIBIANS COLLECTED IN THE PORT HARCOURT AREA OF NIGERIA.—The following annotated list is in respect of material collected or examined by the author during the period of May to November, 1951. All specimens were taken within an approximate radius of 12 miles of Port Harcourt. This area is situated on the eastern fringe of the Niger Delta, and consists mainly of the port, township, European residential district, native villages, and terrain characterized by secondary jungle and mangrove swamps. The climate is that of the equatorial rain forest. A few meteorological data for the year 1950 are given (Table I) for the interest of those concerned with the care of living specimens.

TABLE I

METEOROLOGICAL DATA FOR PORT HARCOURT AREA DURING 1950

Situation:	Shade temp., °C.		Relative humidity	
	Average daily max.	Average daily min.	Average daily max.	Average daily min.
Port Harcourt	31	22.5	99.5	65
Jungle clearing	27.5	22	98	76
Jungle undergrowth	27	21.5	99.5	87

The author wishes to thank Mr. Arthur Loveridge of the Museum of Comparative Zoology at Harvard College for invaluable assistance in the determination of specimens, also Dr. H. W. Parker of the British Museum (Natural History) for information on several points; responsibility for the use of names, however, rests entirely with the author.

Specimens from the author's collection representing the majority of species and subspecies listed below, and indicated by an asterisk, are now incorporated in the collection of the Museum of Comparative Zoology at Harvard College. In the following list, wherever the number of specimens encountered exceeds three, mention of this has been made.

SAURIA

* *Hemidactylus brooki angulatus* Hallowell.—Abundant in Port Harcourt where they are to be found on trees, inside dwelling places, and on the outer walls of buildings. The largest male, received from the jungle, measures 70 mm. from snout to anus, with tail 71 mm., of which a part has been regrown.

* *Hemidactylus fasciatus fasciatus* Gray.—Not encountered in Port Harcourt, but several specimens were taken on the outer walls of some buildings in the jungle.

Agama agama (Linné).—Abundant everywhere in the haunts of man. These lizards sometimes become remarkably tame, and several regularly entered the author's room to take food from his fingers; cake, pastry, chocolate and biscuit were all eagerly devoured.

The incubation period of 3 eggs kept between layers of damp cotton wool, at normal room temperature in Port Harcourt, was a little less than 3 months, i.e., laid June 15 and hatched September 9. The snout to anus and tail measurements at the time of hatching were: 35 + 72, 36 + 72 and 37 + 76 mm.

* *Holaspis guentheri* Gray.

* *Mabuya blandingi* (Hallowell).—Very common in Port Harcourt.

* *Mabuya maculilabris maculilabris* (Gray).—Also very common in Port Harcourt. This and the preceding species were found living in close association with one another.

* *Melanoseps occidentalis* Peters.—One specimen. There appears to be no published record of the species from Nigeria.

* *Chamaeleo cristatus* Stutchbury.

Chamaeleo oweni Gray.—Fairly common in the jungle but none found in Port Harcourt. Although this species is included by Pasqual (1937, Nigerian Field, 6 (1): 32–34) in his key to Nigerian chameleons, and there is a specimen in the British Museum (Natural History) labelled as from "Bonny or New Calabar," there does not appear to be any previously published record for Nigeria.

Serpentes

Python regius (Shaw).

Boaedon lineatus Duméril and Bibron.—A single specimen. Scales in 25–29–19 rows; ventrals 212; anal 1; subcaudals 66. Total length 339, tail 57 mm.

* *Boaedon virgatus* (Hallowell).—A single male. Scales in 22–23–17 rows; ventrals 192; anal 1; subcaudals 62. Total length 437, tail 73 mm.

* *Mehelya crossi* (Boulenger).—A male and a female of this little-known snake were killed by night-watchmen in Port Harcourt. With the exception of some of the following details, both agreed with the description given by Loveridge (1939, Bull. Mus. Comp. Zool., 86: 135).

Male received on October 28, badly mutilated and only the head preserved. Scales in 21–17–17 rows, strongly keeled, many with tubercles and/or indistinctly striated (to form a herring-bone pattern), the vertebrals enlarged, hexagonal and very strongly bicarinate. Ventrals 226, with lateral keels; anal 1; subcaudals 57, paired. Frontal a little shorter than its distance from the rostral. Eye greater in diameter than its distance from the mouth, larger than the nostril. Postoculars 2 (left), but on the right side the upper postocular is almost completely fused with the supraocular. Five infralabials in contact with anterior genials, the latter longer than the posterior pair. Brown above; yellowish white below, outer margins of ventrals and subcaudals pale brown. Total length 1330; tail 190 mm.

Female received on November 4. Scales in 19–17–17 rows, strongly keeled (except row 1 on each side which is indistinctly keeled), many with tubercles; vertebrals enlarged, hexagonal and very strongly bicarinate. Ventrals 241, with indistinct lateral keels; anal 1; subcaudals 51, paired. Frontal shorter than its distance from the rostral. Diameter of eye equal to its distance from the mouth. Temporals 1 + 2 (left) and 2 + 2 (right), the right upper anterior quite small. Five infralabials in contact with anterior genials, the latter longer than the posterior pair. Slatey brown above; dark cream below, the dorsal color extending onto lateral margins of ventrals; lower aspect of tail greyish. Total length 1530; tail 170 mm.

* *Mehelya guirali* (Mocquard).—A male found injured on the road after dark on May 17. This specimen agrees with the description by Loveridge (1939), except that there are 8 supralabials, of which the 4th, 5th and 6th enter the eye. Although known from Liberia to the Belgian Congo, there appears to be only one previous record (as Oil River) of this species from Nigeria.

Mehelya poensis (Smith).

* *Gastropyxis smaragdina* (Schlegel).—A male taken on October 8. Scales in 15–15–11 rows. Ventrals 153; anal 2; subcaudals 166, paired. One pre-, 3 postoculars. Temporals 1 + 2, with an additional small squarish scale between the middle postocular and anterior temporal on the right side. Supralabials 9, the 5th and 6th entering eye. Infralabials 9 (left) and 10 (right), the first 5 in contact with anterior genials. Total length 1047, tail 432 mm.

* *Dasypeltis scaber fasciatus* A. Smith.—A female received on October 27. Scales in 27–23–19 rows, strongly keeled, many of the keels serrated. Ventrals 243; anal 1; subcaudals 79. Length of eye ⅙ that of head. Total length 869, tail 140 mm.

* *Boiga pulverulenta* (Fischer).

* *Crotaphopeltis duchesnii duchesnii* (Boulenger).

Psammophis sibilans sibilans (Linné).

* *Thelotornis kirtlandi kirtlandi* (Hallowell).

Naja nigricollis nigricollis Reinhardt.—The most frequently seen snake in Port Harcourt.

* *Causus rhombeatus* (Lichtenstein).

Bitis g. gabonica (Duméril and Bibron).

* *Atheris chloroechis* (Schlegel).

SALIENTIA

Xenopus tropicalis (Gray).—Nine specimens received on October 12. Several kept alive for a short time fed readily on grasshoppers and other non-aquatic insects thrown onto the surface of the water. It was said that this frog is sometimes eaten by Africans.

Bufo regularis Reuss.—Very common. Examination of many specimens from different parts of the area has shown this to be a small form compared with that found at Kano in northern Nigeria. A typical male and female from Port Harcourt measure, from snout to anus, 66 and 80 mm., respectively.

* *Hyperolius burtoni* (Boulenger).—Undoubtedly the commonest *Hyperolius* in the locality, although this appears to be the first published record for Nigeria. A male and female taken in coitu on August 9 measured, from snout to anus, 18 and 25 mm. respectively, and had spawned by the following morning. Coloration is extremely varied and of 9 males taken on August 9 the dorsal color, in life, of 3 (20, 20 and 21 mm.) was green, of 4 (17, 19, 19 and 20 mm.) brownish yellow to a darker brownish hue, and of 2 (18 and 19 mm.) brown mottled with pale yellow, both with a pale dorso-lateral band; all 9 specimens were whitish on the belly, with the gular region yellow. Six females were found to vary from green to olive above, and were white on the belly with a variable amount of dark spotting.

* *Afrixalus* sp.—A male and female taken from a stagnant pool in the almost dry bed of the small Wankose River on June 1.

* *Afrixalus platyceps* (Boulenger).

* *Leptopelis aubryi* (A. Duméril).—Common.

* *Leptopelis millsoni* (Boulenger).

* *Rana mascareniensis mascareniensis* Duméril and Bibron.—This very common frog frequents even small puddles of rainwater, from whence it croaks in loud chorus.

Rana oxyrhynchus gribinguiensis Angel.—Common, but not quite so numerous as the preceding species.

* *Rana subsigillata* A. Duméril.—J. D. ROMER, *c/o Urban Council Offices, Hong Kong.*

COLORATION OF THE SNAKE *ELAPHE MOELLENDORFFI*.—In March, 1952, I had the good fortune to see for the first time living examples of the little-known snake *Elaphe moellendorffi* (Boettger). Two specimens were obtained from a snake-selling establishment in the Colony of Hong Kong where they were said to have been received during the latter part of 1951 from Yungning (Nanning) in Kwangsi Province, China. On referring to the standard works by Pope (1935, The Reptiles of China: 250) and Smith (1943, The Fauna of British India, III. Serpentes: 153–54), it was at once apparent that the coloration of this beautiful species had been described from preserved material, in consequence of which these descriptions fail to express the real beauty and vivid coloration seen in living specimens. The principal differences are that (in life) the dorsal ground color of the body and upper surface of the head are not gray but are bright olivaceous green and bright brownish red respectively.

The following description is based on the two specimens referred to above, as examined alive in natural light. Dorsal aspect of body bright olivaceous green, with a median series of 28–30 large, squarish, darker (olive to brown), black-edged markings extending from the neck to just in front of the vent, and an alternating series of similar but smaller ones on each side. Many of the scales bordering the black edges of these markings are partially white, thereby producing an indistinct reticulate white margin the extent of which increases on the posterior part of the body where the interspaces between the dark markings (in the median series) are conspicuously whitish. On the tail these markings form 12 dark reddish brown, black-edged, transverse bars with bright red interspaces. Head uniformly bright brownish red above, becoming gray on the lips and whitish on the chin and throat. Ventral aspect of body black and white (or the latter yellowish white) in a more or less checkered pattern, that of the tail a variegation of red and black.

Both specimens described above are females, the lepidosis of the heads agreeing well with the descriptions given by Pope and Smith (*loc. cit.*). Other details are as follows:

	Specimen No. 1	Specimen No. 2
Dorsal scales	25-27-19	25-27-21
Ventrals	276	269
Anal divided	Yes	Yes
Subcaudals (paired)	100	98
Total length (mm.)	1,715	1,915
Tail (mm.)	308	340

It seems probable that the figure "595 mm." as given for the tail of a 1,600 mm. male (vide Smith) is an error and should, perhaps, be 295 mm.

I have been able to trace only one description of *E. moellendorffi* which appears to be based on living material. This is contained in a paper in Chinese by Cheung Mang Mun (1940, Science (published by the Chinese Science Association), 24: 657–70), whose notes on coloration agree in all essential respects with mine. Cheung remarks that the native name "Hundred-Flower Snake" signifies its beauty.

I am grateful to Professor David Barker of Hong Kong University for kindly bringing to my attention the presence of these snakes on the local market. —J. D. Romer, *% Urban Council Offices, Hong Kong.*

EARLY RECORDS OF THE SEASNAKE *PELAMIS PLATURUS* IN LATIN AMERICA. —Some time ago in a paper dealing with the Costa Rican ophidian fauna (1951, Univ. Kansas Sci. Bull. 34 (1): 1–188), I suggested (pp. 12–13) that, since there had been so little change in the characters of the seasnake *Pelamis platurus* (Linnaeus) as found along the Pacific Coast of Central and South America from characters obtaining in that species in Asiatic waters, the species may have been brought to the American coast in historic times by chance on vessels plying across the Pacific Ocean. That such is not the case, and that the arrival of the form antedates written history of the region, is shown by certain historical documents. These were called to my attention by Prof. Jorge León of the Inter-American Institute of Agricultural Sciences of Turrialba, Costa Rica.

Gonzalo Fernández de Oviedo y Valdes (Historia general y natural de las Indias, Book X) reports that on the 25th of September, 1513, Vasco Nuñez de Balboa discovered the Pacific Ocean, and the 29th he took possession in the name of the King and Queen of Spain. Governor Pedrarias Dávila, in 1519, sent his Alcalde Mayor, Licenciado Gaspar de Espinosa, on a voyage of discovery in the Pacific to the west.

The expedition followed the coast line west and north around western Panamá and Costa Rica. It entered the Golfo de Nicoya enclosed by the Peninsula de Guanacaste, rounded the peninsula and sailed north to discover the Bahia de Culebras. In the words of Oviedo (Book X, Chapter 13):

> "En este camino que en la mar del sur hizo el Licenciado Espinosa, está é se descubrió aquel golfo que se llama de las *Culebras*, porque hay innumerables, que se andan sobreaguadas en la mar, de tres palmos é poco más luengas, todas negras en los lomos, y en lo de abajo de las barrigas todo amarillo, é de lo negro bajan unas puntas: é de lo amarillo suben otras, que se abrazan unas con otros, como quien enteretejiese los dedos de las manos unos con otros, así estos dos colores se juntan: las mas gruesas dellas son más gordas quel dedo pulgar del pie ó como dedos de la mano juntos, e de allí más delgadas otras."

Another early report, that of Ravenau de Lussan (1693, Journal du Voyage fait a Mer du Sud, Paris: 120), likewise states that these serpents are in abundance. He says (free translation):

> "Water serpents about two feet in length abound. Their bite is venomous and mortal, and there is no human remedy that is able to prevent a sudden death to a person once bitten. There is one curious fact that when the dashing of the waves throw these reptiles on shore, scarcely do they touch the sand when they die, even though they do not leave the water."

Since the color description points to this species so certainly, there can be no mistake in identifying the species with *Pelamis platurus*.

It must therefore be obvious that, before any known voyages had been made across the Pacific Ocean, this species of serpent abounded on the coast of Costa Rica.—Edward H. Taylor, *Museum of Natural History, University of Kansas, Lawrence, Kansas.*

ON THE TYPE LOCALITY OF SOME BRAZILIAN REPTILES AND AMPHIBIANS COLLECTED BY H. H. SMITH AND DESCRIBED BY E. D. COPE.—In 1885, Cope (Proc. American Philos. Soc., 22: 185–94) published a list of the herpetological specimens sent to him by the famous collector H. H. Smith. He stated (p. 185): "The Naturalist Brazilian Exploring Expedition, under the direction of Mr. Herbert H. Smith, commenced its work in the Province Rio Grande do Sul. The principal collections were made at Sao Joao do Monte Negro." The forms described as new in this paper are *Paludicola ranina*, *Amphisbaena trachura*, *Aporarchus prunicolor*, *Phalotris melanopleurus*, *Opheomorphus fuscus*, *Aporophis cyanopleurus*, and *Helicops baliogaster*.

Later (1887, Ibid., 24: 44–60), Cope published a list of herpetological material sent by the same H. H. Smith, this time from Chapada, Mato Grosso, the best known of Smith's localities. Cope begins this 1887 paper with a statement that flatly contradicts his earlier one, for he says: "The Naturalist Brazilian Exploring Expedition commenced its work in the province of San Paolo. From the neighborhood of Sao Joao do Rio Negro a collection of Batrachia and Reptilia was forwarded to the writer, and a list of them was published in the Proceedings of this Society, 1884, p. 185."

Two major discrepancies should be noticed: (a) the first Province (now considered a State) visited by Smith is said to be São Paulo, instead of Rio Grande do Sul; (b) the principal collecting station of this period is now São João do Rio Negro, and not São João do Monte Negro, as it had been stated before.

As an appendix to the Chapada list Cope published (*loc. cit.*: 60) the description of a "Leptognathus from San Paolo," *L. garmani*, based on a specimen listed in 1885 as *L. catesbyi*. The type locality was said to be "São João do Rio Negro." This appendix is thus in agreement with the second list, not with the first.

In Fox's first report on the Hymenoptera collected by Smith (1896, Proc. Acad. Nat. Sic. Phila.: 292–307), there is a short but adequate description of the collector's travels; it reads as follows:

> In 1873–1875, Mr. Smith worked alone on the Amazons, and the Santarem material was then gathered. In 1881–1886, accompanied by his wife and two assistants, another journey was made. Going first to Pará he and his wife made a flying trip to Santarem, and then down the coast, stopping a week at Pernambuco and several months at Rio de Janeiro. From the latter place they went to Entre Rios. Six months were spent in Rio Grande do Sul; but there are no hymenoptera in the collection from that place. By steamer they proceeded up the Paraguay to Corumbá and Cuyabá. Headquarters were established at Chapada, and there four years were spent. Ad interim Mr. Smith returned to Rio de Janeiro for a year, leaving his wife and one assistant in the interior. After finally leaving Chapada they made a canoe journey on the Upper Paraguay to Pedra de Amolas, Pacoval, etc, but most of the time was here given to geological and ethnological work. Subsequently several weeks were spent at Corumbá and Piedra Blanca, before returning to the United States.

As Fox's notes were based on H. H. Smith's personal information, I believe this evidence to be decisive as to the Brazilian states visited by Smith and his party. São Paulo was evidently not explored.

Internal evidence from the collections points to the same conclusion. *Anopsibaena kingi* (*Anops kingii*, Cope), *Teius teyou* (*Acrantus viridis*, Cope), *Liophis miliaris semiaureus* (*Opheomorphus fuscus* Cope), *Micrurus frontalis altirostris* (*Elaps altirostris* Cope), *Bufo d'orbignyi* and *Pseudis mantidactyla* are forms which are characteristic of southernmost Brasil and have not been found in São Paulo.

There is a locality of the name São João do Monte Negro in Rio Grande do Sul near Porto Alegre, capital of the state. This place is plotted on the October 1950 map of South America of the National Geographic Magazine, under the name Montenegro in the J7 square. I believe that this city in the Municipio (County) of Porto Alegre must be taken as the type-locality of the new species described by Cope (1885, Proc. Amer. Philos. Soc., 22: 185–94) and of *Leptognathus garmani* (1887, *Ibid.*, 24: 60) mistakenly stated to have come from the state of São Paulo.—P. E. VANZOLINI, *Department of Zoology, Caixa Postal 7172, São Paulo, Brazil.*

NOTES ON REPTILES AND AMPHIBIANS FROM EL VOLCAN DE CHIRIQUI, PANAMÁ. —From December 3 to 14, 1948, Dr. P. F. Scholander and the writer, accompanied by Mr. Carlos E. Hooker, visited el Volcan de Chiriqui to collect material for the physiology program of the Arctic Research Laboratory. Mr. Tollef Monniche, owner of Finca Lerida, a coffee plantation 5 km. west of Boquete, generously let us use Casita Alta as a base camp for our work on the eastern slope of the volcano. Mr. Kurt Hammerling of Bambito provided us with guides for our climb up the western slope to the crater. The field work was supported through contract with the Office of Naval Research (Arctic Research Laboratory, Pt. Barrow, Alaska).

El Volcan de Chiriqui, the highest mountain in Panamá (elev. approx. 11,500 feet), lies in the western part of the republic near the Costa Rican border. The volcano is well forested except for the llano, portions close to and in the crater, and cultivated areas. The llano, an old lava flow on the western slope, is crossed by the deep gorge of the Chiriqui River. Except for scattered islands of forest rising out of the lava bed, the llano is characterized by occasional boulders, isolated small trees, short grasses, and a few agaves. Two ravines are present on the llano; during our visit one was dry but there was a stream several hundred feet in length in the other. The vegetation in the ravines was more luxuriant than on the llano itself.

In the higher altitudes (above 9000 feet) of the eastern slope of the volcano, the bamboo, moss- and lichen-covered trees, and bromeliads were kept wet by the *bajareque*, a soaking mist characteristic of high altitudes in the region. The western slope was not as moist in the higher elevations, the vegetation above 8000 feet was not as luxuriant, and the trees were not clothed with such great masses of lichens, mosses, and bromeliads as on the eastern slope.

The party of which the writer was a member visited the main crater and found the Inter American Geodetic Survey marker atop the northwest wall. The floor of the main crater consists of ash and rocks. Grasses grow on the ash and lichens on the rocks; shrubs are occasional on the floor of the crater. Protected portions of the north wall and a small portion of the south wall have small trees but otherwise lichens, mosses, ferns, and small flowering plants dominate the scene. There was no free surface water in the crater during our visit (Dec. 10–12) but the rocks were frequently moistened by passing clouds (*bajareque*) and mornings were misty. The foregoing description of the crater differs in some respects from Slevin's description (1946, Herpetologica, 3: 62–63). Slevin reported a spring in the north wall of the crater, but we found none. It is probable that one may exist under certain climatic conditions, since Slevin's trip took place in August 1937 whereas ours occurred in December 1948. Slevin mentioned that when his party reached the top they came to an opening in the trees and looked down into the crater. We did not find the crater to be rimmed by trees; the trees thin out considerably at some distance below the rim and are very sparse on the rim and outer wall of the crater. It is possible that Slevin may have

visited a different crater lying at a lower elevation. Slevin gave the elevation of the crater as about 1000 feet. This is evidently a typographical error since all elevations for miles around are in excess of 3000 feet.

Above 9000 feet the air was always cool; the highest shade temperature measured was 11° C. at 6 PM at 9500 feet on the eastern slope. Above 11,000 feet the shade temperature ranged from 8° to 10° C.; these readings were taken in the morning before the day's work was begun. The Chiriqui and Caldera rivers were stocked with rainbow trout (*Salmo gairdneri*) by Mr. Monniche some time ago; that trout can survive and breed in these Panamanian waters is indicative of the cool climate of the volcano.

During spare moments the writer observed and collected a few reptiles and amphibians. A total of seven species of salamanders, frogs, and lizards were collected. Dr. E. R. Dunn very kindly identified the species of *Eleutherodactylus* and *Anolis*; Mrs. Bessie M. Hecht identified the other species.

Magnadigitata subpalmata (Boulenger).—Eight specimens were found under stones and pieces of wood on the southwest inner wall of the crater (elev. approx. 11,300 feet). Slevin collected his specimens on the north wall and on the floor of the crater; the writer did not find any salamanders in either of these places, perhaps because the crater may have been drier when we visited it. The specimens collected by the writer ranged from 31 to 62 mm. in snout to vent length. Two principal color phases of the dorsum were evident, but there was some integradation in the patterns. The dark phase was black with faint brown flecks on the dorsum and brownish buff blotches on the sides while in the pale phase there was an irregular black-flecked chestnut brown mid-dorsal stripe from the snout to the end of the tail and the sides were blotched with brownish buff. Two of the animals collected were of the dark phase and 6 were of the pale phase. The animals wrapped their tails about the writer's fingers when they were collected. The salamanders made no attempt to bite, although Dunn (1926, The Salamanders of the Family Plethodontidae: 392) reported that a Costa Rican specimen tried to bite him. Slevin described the moss under which the animals were found as ice cold; the moist ground (mainly moss) where the writer collected the animals was cold but its temperature was not measured. The animals were very sluggish when found.

Eleutherodactylus punctariolus (Peters).—A single specimen was found beneath a rock in a stream in a ravine on the llano (elev. approx. 6000 feet).

Eleutherodactylus rhodopis (Cope).—Two specimens were found hopping about in the forest at 6000 and 7000 feet on the eastern slope of the volcano.

Anolis pachypus (Cope.)—Five specimens were taken between 4500 and 7000 feet on the eastern slope but the species was not seen at higher elevations.

Anolis pentaprion (Cope).—A single specimen was found 4 km. west of Cerro Punta (western slope) at about 6000 feet. The angles of the jaws were turquoise and the dewlap was red. The animal made squeaking sounds when held.

Scelo porus malachiticus malachiticus (Cope).—This species was abundant on boulders and under trash, but very wary and agile, on the llano at 5000 to 6000 feet, where only one specimen was taken; at higher altitudes the lizards were sluggish; a specimen was found on a boulder in a rock-filled lesser crater next to the south wall of the main crater (11,200 feet); another was found on the wall of the shed at Casita Alta (eastern slope) at 7000 feet. The animals on the llano appeared to be larger and more brilliantly colored than those from higher altitudes. The 62 mm. (snout to vent) male from the llano had brown and green stripes with faint traces of dark bands on its dorsum; the posterior half of its throat was bright blue followed by a black gular band; the venter was pale blue with a black-edged indigo belly patch on each side. The 38 mm. (snout to vent) male from the crater had a faint greenish tinge to the dark-striped and dark-banded dorsum; the entire throat was dusky blue but there was no gular band; the venter was dirty white with diffuse pale blue belly patches which lacked black borders. The highest altitude listed for this subspecies by Smith (1939, Field Mus. Nat. Hist., Zool. Ser., 26: 1–397) is 3000 meters (Volcan Irazu, Costa Rica); the present record from the crater raises the vertical limit to 11,200 feet.

Barisia monticola (Cope).—One specimen was collected at Casita Alta (elev. 7000 feet) on the eastern slope; one in a dry stream bed (elev. 8000 feet) on the western slope; and another in the crater (elev. 11,200 feet). All three specimens were leisurely walking about in the open when found and made no attempt to escape. This species exhibits marked sexual dimorphism in color pattern; Slevin (1946, *ibid.*) described the color patterns of animals from the volcano.

Three species (*Magnadigitata subpalmata*, *Scelo porus m. malachiticus*, *Barisia monticola*) were found within the crater, at 11,200 feet or higher; two (*S. m. malachiticus*, *B. monticola*) were also taken by the writer at much lower elevations on both the eastern and western slopes of the volcano, while the third (*M. subpalmata*) was listed by Dunn (1926, *op. cit.*) as *Oedipus subpalmatus* from Boquete on the eastern slope at 3700 feet. Slevin (1946, *op cit.*) did not list *S. m. malachiticus* in his report of animals found in the crater.

It is likely that future investigators of this highly interesting area will record more species from the crater. The flora, which is alpine in affinity, contrasts

strongly with the tropical herpetofauna in the crater. —VLADIMIR WALTERS, *Department of Biology, New York University, University Heights, New York 53, New York.*

RECORDS OF THE GREEN WATERSNAKE, *NATRIX CYCLOPION FLORIDANA*, IN SOUTH CAROLINA AND GEORGIA.—Goff (1936, Occ. Pap. Mus. Zool. Univ. Mich., 327: 1) reported *Natrix cyclopion floridana* from Gough, Berkeley County, South Carolina. No other South Carolina record has been published. The following observations therefore seem of interest.

Goff did not make clear which of his specimens were from South Carolina. Actually, three Charleston Museum specimens, included among his paratypes, afforded the basis for the record. All three were from the ricefields of the old Richmond Plantation, on the upper Cooper River a few miles west of Gough. James E. Mosimann informed the authors (*in litt.*) that a fourth specimen from this locality, Charleston Museum No. 33.53.1, had been given to Clemson College.

The senior author recently examined the specimens of *Natrix cyclopion* in the Charleston Museum collection. A few South Carolina examples were noted in addition to Goff's paratypes. Ch. M. No. 41.103 was taken in Berkeley County at Fairlawn Reserve, about 18 miles northeast of Charleston, Charleston County, by E. B. Chamberlain, on June 14, 1940. According to Mosimann, it was found in a small buttonbush about 14 inches above water level in a cypress backwater. On August 15, 1940, this snake gave birth to 7 young. These were preserved as Ch. M. No. 40.150. Mosimann stated that Chamberlain found a green watersnake at Mulberry Plantation on the upper Cooper River, Berkeley County, on January 29, 1931. This specimen was not preserved.

The Charleston Museum has five additional records of *Natrix cyclopion* from the vicinity of Gough. The snakes were not preserved. They were taken on the following dates: March 28, 1933; March 5, 1935; April 6, 1936; February 23, 1941; and December 19, 1943.

Raymond L. Ditmars, in a letter dated January 5, 1927, to Franklin Sherman, stated that he collected a green watersnake in Hampton County, South Carolina (*fide* Mosimann). However, in none of his writings did Ditmars credit *Natrix cyclopion* to South Carolina.

The junior author recently procured a green watersnake from the vicinity of Barnwell, Barnwell County, South Carolina. The specimen is No. 17453 in the collection of E. Ross Allen and the senior author. Apparently this is the first record of the species in the upper Atlantic Coastal Plain, but its existence here is not particularly surprising. Suitable habitats for this snake occur in many places along the Salkehatchie (Combahee) River, from the Barnwell region southeastward to the coast.

Goff (*op. cit.*) mentioned a green watersnake from Beachton, Grady County, Georgia. It was said to have been somewhat intermediate between *Natrix c. cyclopion* and *N. c. floridana*. There is no other published Georgia record for the species, as far as the authors are aware.

Four green watersnakes, Nos. 17454–57 in the Allen-Neill collection, were taken on the outskirts of Valdosta, Lowndes County, Georgia, in July, 1952. Two other examples, both large adults, were also captured there, but were not preserved.

The Georgia and South Carolina specimens are apparently referable to the subspecies *floridana*. They differ but slightly from topotypical Florida examples. One of the Valdosta snakes displays heavier and more extensive gray ventral markings than is usual with this race.

The authors are grateful to James E. Mosimann for information about material in the Charleston Museum collection.—WILFRED T. NEILL AND FRANCIS L. ROSE, *Research Division, Ross Allen Reptile Institute, Silver Springs, Florida,* and *Augusta, Georgia.*

THE TREEFROG, *HYLA SEPTENTRIONALIS*, IN FLORIDA.—The giant treefrog was first reported in Florida at Key West (Barbour, 1931, COPEIA (3): 140), and two examples were taken in 1940 on Stock Island, which adjoins Key West (Wright and Wright, 1949, Handbook of Frogs and Toads, 3rd ed.: 338). One specimen was seen on Upper "Matacumba" (Matecumbe) Key in 1946 (Trapido, 1947, Herpetologica, 3: 190). Recently a colony of these frogs was found in Miami, on the Florida mainland (Schwartz, 1952, COPEIA (2): 117). Additional records of the species are now at hand.

On November 16, 1951, Roger Conant and the senior author took five specimens of *Hyla septentrionalis* on Upper Matecumbe Key. These are preserved as Nos. 4341–45 in the Allen-Neill collection. All were small, and one must have recently transformed, for it was but 22 mm. in snout–vent length. Evidently the species is breeding on this island. A larger specimen (No. 4346) was taken farther north near Rock Harbor, on Key Largo; this seems to be the first published record for the island. Another (No. 4340) was taken on Big Pine Key, January 10, 1949, by Gordon Battey; the species has not been reported there previously.

Erwin Winte called the authors' attention to the occurrence of *Hyla septentrionalis* at what was formerly Royal Palm State Park, Dade County. He stated that certain naturalists brought the species to that locality from Key West before the State

Park was encompassed by the Everglades National Park. Mr. Winte, a Park warden, is well acquainted with the southern Florida herpetofauna, and the authors feel that his record is trustworthy even though no example from the locality is at hand.

Specimens of *Hyla septentrionalis* feed voraciously on other frogs. Breeding individuals of this form often devour other species of frogs that attempt to utilize the same breeding ponds. The establishment of the giant treefrog is likely to have an adverse effect on some of the native forms, and especially on the small, restricted Key populations.—E. Ross Allen and Wilfred T. Neill, *Ross Allen Reptile Institute, Silver Springs, Florida.*

JUVENILES OF THE TORTOISE *GOPHERUS POLYPHEMUS*.—Apparently the juveniles of the gopher tortoise have not been previously described. They differ considerably from the adults, as the following account indicates. (Parenthesized color notations are from Maerz and Paul's Dictionary of Color, 2nd ed.)

At hand is a juvenile gopher tortoise with a carapace length of 54 mm., straight line measurement, taken near Silver Springs, Marion County, Florida, on April 30, 1952. It is probably about 6 months old. In this specimen, the head is mostly dull yellowish-orange (12G7), becoming somewhat more orange (12I9) toward the snout. The region about the eye is greenish-gray (13D3), and the margin of the upper jaw is light tannish (12C5). A small area just back of the gape is light orange (11H7). The neck is dull yellowish (12C6). The forelimbs are mostly dull orange-yellow (11I7). Some of the enlarged scales of the forelimb are a deeper orange (11I9). There is a dark grayish (8A1) stripe along the upper edge of the forelimb and a similar stripe along the lower edge. The hindlimbs are mostly dull yellowish (12C6), varying in places to orange (12I9). There is a dark grayish (8A1) stripe down the back of the hindlimb, extending from the base of the tail to the foot. Below this stripe is an elongate spot of similar hue, suggesting a second stripe. The tail is orange (12I9), with a grayish (8A1) stripe along each side. The vertebral and costal shields are corn yellow (10J5), each bordered narrowly with brownish (13C9) and broadly with a dark brownish-black (not listed). Above, the marginals are orange (11H8) to orange-yellow (10I7), variously stippled with brownish-black. The plastron is light yellow (10H5), varying to orange-yellow (9K7), and becoming Mikado orange (9J9) toward the bridge. The under side of the marginals is bright orange (9K10).

Newly hatched gopher tortoises are even brighter in coloration than the specimen described above.

Young gopher tortoises lack several of the morphological specializations that characterize the adults. In juveniles, the feet are not especially "stumpy", and the claws are long and sharp. The gulars do not project forward, the anterior margin of the plastron being truncate. Both carapace and plastron are quite flexible, not rigid.

Carr (1952, Handbook of Turtles: Pl. 64, C) figured a young gopher tortoise from Marion County, Florida. This specimen, along with nine others, was collected by the senior author near Silver Springs in September, 1937. Probably these turtles had hatched no more than two or three weeks previously. They were all found in about two acres of turkey-oak woods. Each little turtle had excavated a burrow in the sandy soil. The burrows were never more than 30 inches long, and usually opened under a clump of wire-grass or beside a fallen log.

A gopher tortoise, collected at Silver Springs on May 2, 1952, measured 111 mm. in carapace length, and probably was about 18 months old. In this specimen the plastron and under side of the marginals were light yellow (11H3). Otherwise the turtle resembled larger adults in coloration as well as in morphology.—E. Ross Allen and Wilfred T. Neill, *Ross Allen Reptile Institute, Silver Springs, Florida.*

CASE REPORT OF A BITE FROM THE MASSASAUGA, *SISTRURUS CATENATUS CATENATUS*.—A small massasauga, captured May 30, 1952, at Wheeling, Illinois, was kept in a terrarium at my home in Harvey, Illinios. On June 11, 1952, a group of friends and I were taking motion pictures of the snake. I had become so familiar with handling it that I carelessly attempted to smooth down a turned up scale after returning the snake to its box, and received a bite from both fangs just above the nail on the left first finger. The snake, a male, is 451 mm. in length (17¾ inches.)

The bite took place at about 5:00 PM. We first applied a tourniquet above the elbow. The wound area and a single-edged razor blade were sterilized with iodine and three cross-cut incisions were made, one on each fang mark and one slightly above, toward the hand. Suction was then applied with two Asepto cups. I was then driven to the doctor's office, which we reached at 5:07. When Dr. John Dwyer arrived, a few minutes later, he first injected 15 mg. of Demoral at the base of the finger. At that time, within a half-hour of being bitten, I had a strong nervous reaction. I broke out in a cold sweat and felt extremely faint and nauseated. The doctor made six short but deep longitudinal incisions at the base of the finger. An additional suction cup was added to the two which had been in continuous operation. I had been kept sitting in a chair, and felt much better when (after some argument) I was allowed to lie down in the emergency room.

Test with horse-serum turned out negative, and

I was then given 15 cc. of anti-crotalid antivenin, injected in the buttocks. After being admitted to the hospital, I was injected with 600,000 units of penicillin and 1 g. of streptomycin; and after another negative skin test, I received 5000 units of tetanus antitoxin and 4000 units of gas gangrene antitoxin. Suction was kept up continuously until 9:00 PM. Hot fomentations were then alternated with suction. My hospital record was as follows:

9:30 PM	urinated
9:45–10:00	suction
10:00–10:55	hot fomentations
10:00–10:35	enema
10:55–11:10	suction
11:00–12:00	hot fomentations
11:10	sedative gr. 155 Seconal
12:05–12:20 AM	suction
12:20–1:20	hot fomentations
1:22–1:38	suction
1:38–2:27	hot fomentations
2:27 2:42	suction
2:42–3:50	hot fomentations
3:05	urinated
3:50–4:05	suction
4:05–4:55	hot fomentations; fell asleep
4:45–5:10	hot fomentations
5:00	pulse rate low; blood pressure normal
5:30	pulse normal
6:15–10:00	hot fomentations
8:30	awoke; blood test; ate lightly
9:30	600,000 units penicillin; 1 gram streptomycin
10:00–10:15	suction
10:15–11:30	hot fomentations
11:13–11:50	suction
11:52–2:00	hot fomentations
12:00 PM	ate a light lunch
2:00–3:30	hot fomentations
3:15	pulse and temperature normal
3:30–4:15	hot fomentations
4:00	600,000 units penicillin; 1 gram streptomycin
4:15	wounds dressed with antiseptic ointment and gauze; left hospital at 5:00 PM

While I was at the hospital, I ate lightly and drank a great deal of fruit juices and water.—JOE LAPOINTE, *15625 Vine Avenue, Harvey, Illinois.*

NOTEWORTHY AMPHIBIAN RECORDS FROM INDIANA DUNES STATE PARK.—In the course of repeated trips to the Indiana Dunes Region (Porter County, Indiana) for herpetological studies, a number of amphibians have been taken that represent species very rarely collected in the Dunes area. The specimens in question are preserved in my private collection or in the Chicago Natural History Museum.

Ambystoma opacum Gravenhorst.—Only four specimens of *Ambystoma opacum* have been reported from Porter County (Schmidt and Necker, 1935, Bull. Chicago Acad, Sci., 5: 60; and Necker, 1939, ibid., 6: 3).

Two additional specimens were found in the low swamp forest association near the center of the Indiana Dunes State Park. The first specimen was found under a small log about 50 meters from Dune Creek on March 27, 1951. The second was found under a rock at the edge of a dry roadside ditch in front of the Duneside Inn, August 21, 1951, about 300 meters from the first find. The second was collected by Donald Daleske and presented to me by Si and Jean Segal.

Hemidactylium scutatum Schlegel.—The four-toed salamander is rare in the Dunes Region. I have a specimen collected March 28, 1951, on the road that marks the eastern boundary of the Indiana Dunes State Park. The night was warm for March (11° C.), and rainy; the specimen was abroad on the road about midnight.

Bufo terrestris americanus Holbrook.—A specimen was taken March 29, 1951, about 300 meters east of the eastern boundary of the Indiana Dunes State Park in sandy terrain, where the normally expected species is *Bufo woodhousei fowleri*. Subsequently, two specimens were taken within the Park near its western boundary from breeding choruses in puddles along Highway 49, about 600 meters from the beach (April 18 and 27, 1952).

Walter T. Stille in his recent paper on amphibians of the beach proper (1952, Ecology, 33: 145–62, figs. 1–3) does not mention *Bufo terrestris americanus*, with the evident implication that only *Bufo woodhousei fowleri* is to be expected in the sandy terrain of the Dunes.—JOE LAPOINTE, *15625 Vine Avenue, Harvey, Illinois.*

REVIEWS AND COMMENTS

TRAITÉ DE PISCICULTURE. By Marcel Huet. Editions La Vie Rustique, 299 Avenue Georges Henri, Brussells, Belgium, 1952: xiv + 369, paper, illus. Boards, 225 Belgian francs, clothbound, 285 B.f.—Students and teachers of fishery biology will find much of interest in this work, which

was obviously intended by its author to serve as a working handbook for the European fish-culturist. It contains lengthy sections on the culture of carp, of brook, brown and rainbow trout, and of several species of *Tilapia*—a genus of cichlids which M. Huet believes holds much promise as a source of animal protein in the diet of natives of the Belgian Congo (where he worked) and possibly in other tropical regions. There are also observations on the culture of eels, northern pike, various coregonids, and black basses.

General sections of the book deal with design and operation of ponds and hatcheries, and with problems of productivity, stocking rates, fertilization, and weed control. The commercial production of carp and trout for the table receives attention throughout.

The book is liberally illustrated; typography and paper quality are good. Its use to American readers will lie chiefly in the light it throws on present-day fish-cultural problems and methods in Western Europe and Equatorial Africa.—JUSTIN W. LEONARD, *Michigan Department of Conservation, Lansing 13, Michigan.*

WELCHES TIER IST DAS? KRIECHTIERE UND LURCHE. By Robert Mertens. Keller, Stuttgart: 48 pp., 48 pls., 105 textfigs. D.M. 7.50 ($1.80). 1952.—This is a "fieldbook" in the best sense, small enough to be carried into the field, complete enough to serve every identification purpose. Its completeness for the region from Great Britain and Denmark to Switzerland and Austria and from France east of the Seine to western Poland and Czechoslovakia is made possible, of course, by the relatively impoverished fauna of Central Europe (12 forms of salamanders, 15 frogs, 6 lizards, 11 snakes, and 6 turtles—including the marine ones).

By the use of fine print, line drawings carefully selected from the literature, and telegraphic style, together with careful organization of the text, an extraordinary amount of information is compressed into this little book, which has every merit that a book intended for use in the field should have. For good measure there are 48 halftone plates of admirable photographs from life.—KARL P. SCHMIDT, *Chicago Natural History Museum, Chicago 5, Illinois.*

EL SALVADOR BIOLOGISCHE REISEN IM LAND DER VULKANE. By Robert Mertens. Kramer, Frankfurt a/M., 116 pp., 70 textfigs. 1952.—The list of popular books of travel and observation devoted to the countries of Central America, and written by naturalists, is all too short, and there has been none, hitherto, for El Salvador. The occasion for the present small work is the existence of the "Instituto Tropical de Investigaciones Cientificas" of the University of El Salvador, at San Salvador; this institute was established in the hope of drawing other North American institutions, and European ones as well, into cooperative studies of the fauna and flora of El Salvador. As guest of this institute, Robert Mertens, Director of the Senckenberg Natur-Museum in Frankfurt a/M., spent six months in El Salvador, mainly in the interest of herpetological collecting.

With its high proportion of cultivated land and its dense human population, El Salvador offers a quite different framework for studies in natural history than do neighboring Guatemala, Honduras, and Nicaragua, with their extensive areas of unmolested tropical and subtropical forests. The principal agricultural product of El Salvador is coffee, and since Salvadorean coffee plantations, like those of Guatemala, have a considerable remnant of large trees left for shade, they afford a distinct and not unfavorable forest habitat for much of the native fauna. The plantations themselves afford a favorable sphere of operations for a naturalist, especially for the herpetologist. Quite in their original condition are the coastal mangrove zones, various lakes, and a really wonderful island of cloud forest at Miramundo, where El Salvador, Guatemala, and Honduras meet. Dr. Mertens has described the principal types of Salvadorean landscapes, together with their animal inhabitants, among which the amphibians and reptiles appear in their normal relations.

Chicago Natural History Museum has long had an interest in El Salvador, and has sent geological, botanical, and zoological investigators to the new institute. There is much need for a change of emphasis in field natural history from the collecting 'safari,' often a mere transect of a region with numerous short stops for a kind of cream-skimming collecting, to long continued studies, more aware of the regional ecology, and more sharply focussed on the actual *history in nature* of the animals to be studied. For such studies the work must be from an established base and preferably from an at least modestly equipped laboratory. We accordingly maintain high hopes for the future of the *Instituto Tropical de Investigaciones Cientificas*, from which the still necessary biological surveys of the country can be conducted and where more detailed ecological studies can be pursued.—KARL P. SCHMIDT, *Chicago Natural History Museum, Chicago 5, Illinois.*

FUN WITH TROUT. By Fred Everett. The Stackpole Co., Harrisburg, Pa., 1952: 1–287, numerous illustrations (4 pls. in color). $7.50.—A most unusual angling book! Perhaps one would expect this from an author who is first of all an artist by profession and second a writer, but primarily a trout fisherman. Most books on fishing are under-illustrated. Here is one that is not. It could

be enjoyed and mostly understood even by an illiterate. Also it is a beautiful job of printing and book-binding.

The book is properly divided into "sketch groups": the first outlines the reason and need for going trout fishing and the advantages and pleasures of wet- and dry-flying; the second discusses the trouts of northeastern streams and their habits which relate to angling; the third and final "half," as the author terms it, deals with what is wrong with trout fishing on public waters and what can be done to correct it.

Biologists and those charged with the administration of trout fisheries will heartily agree with Everett's statement that "The day of catching trout just for the frying pan is over." Also, most of us will agree with him that "the opening day" should be abolished. Current trout research gives less support for his belief that size limits and creel limits serve no useful purpose and that restricting waters to artificial flies only is unsound. It would seem that these restricting regulations should fit in with his admirable philosophy, oft-time repeated, of more fun from trout fishing, since they can reduce the kill and increase the sport. The author also points at a growing concern among administrators over the fact that the trout fisherman is now getting much more in return for his license fee than he has any right to expect. Rather than continue to spend millions of dollars on trout planting, Everett feels that the anglers' license dollars should be put to work in the restoration of watersheds which will benefit all concerned with soil and wildlife conservation—including the trout fisherman. Truly this is a modern angling book.—ALBERT S. HAZZARD, *Institute for Fisheries Research, University Museums Annex, Ann Arbor, Michigan.*

GUIDE TO THE FISHES OF COLORADO. By William C. Beckman. University of Colorado Museum, Leaflet No. 11: 1–110, figs. 1–14. Dec., 1952. $1.00.—Not since 1914, when *The Fishes of Colorado* by Max M. Ellis was published, has the entire fish fauna of this Rocky Mountain state been treated. Dr. Beckman here describes and keys out 89 kinds (78 species) of fishes now represented in Colorado of which 54 are native, 33 introduced, and 2 have been taken very close to the state's borders. The booklet is essentially a compilation prepared for use by the amateur and beginning student. It is prefaced by an illustrated discussion of how measurements and counts are made and of the structures used in fish classification. Next comes a key to families (with outline drawings of family types) followed by descriptions of each species, including general notes on habitat, life history and distribution in Colorado. There is a key to each genus which contains more than a single species, and every species is represented by a simple line drawing that stresses the major distinguishing features. A short list of general or regional books is given after the descriptive accounts (the absence of references to Ellis and to Forbes and Richardson's *Fishes of Illinois* is notable), and then follows an appendix (glossary of technical terms), a tentative list of species expected to be found in Colorado, and an index (unfortunately to common names only).

Some of the line drawings need improving (the trouts and certain suckers and catfishes, in particular), the standard length is incorrectly portrayed (Fig. 2), and a number of the definitions of technical terms are incorrect, but these can readily be modified in a revised edition. The author has done a creditable job of bringing before the public a popular account of the Colorado fish fauna, with up-to-date scientific and vernacular names. The need for this type of booklet is still great and it is hoped that the publication of the several regional accounts of recent years will serve to stimulate the appearance of other such works.—ROBERT RUSH MILLER, *Museum of Zoology. University of Michigan, Ann Arbor, Michigan.*

CHECK LIST OF THE FISHES OF KOREA. By Tamezo Mori. Mem. Hyogo Univ. Agr., 1 (3), Biol. Ser. No. 1: 1–228, 1 map; 1952.—This is a timely revision of *A Catalogue of the Fishes of Korea* by the same author (1928), which included 386 species, and of *A Revised Catalogue of the Fishes of Korea* by Mori and Uchida (1934), that listed 522 species. This number is increased to 824 in the present memoir. A valuable digest of the literature on Korean fishes, and, of particular value, a list of Prof. Uchida's important life history papers, is followed by the Check List. In this are given, for each species and subspecies, the scientific name, the Japanese name, the habitat, a reference to the original description, and a reference to every real synonym. Berg's (1940) classification has been followed in the main. There are two indices, one to scientific names and the other to Japanese vernaculars.—ROBERT RUSH MILLER.

ZOOLOGICAL RECORD. Vol. 87, Sec. 15 (Pisces), Sec. 16 (Amphibia and Reptilia), containing literature references for 1950. 1952.—The section on Pisces lists nearly eleven hundred references; the one on Amphibia and Reptilia, eight hundred and eighty. Prices are: Pisces 7s. 0d., postage 4d.; Amphibia and Reptilia 7s. 6d., postage 4d. Orders should be sent to the Secretary, Zoological Society of London, Regent's Park, London, N.W.1, England.

Editorial Notes and News

News notes

A NEW series of the *Japan Science Review* will be of interest to members of the Society. This is in the Biological Sciences and presents a comprehensive review through the cooperation of the Zoological Society of Japan, the Botanical Society of Japan, the Genetical Society of Japan, and Nihon Nogaku-Kai (Japanese Association of Agricultural Science). The object of the review is to give the reader a general idea of research in the biological fields in Japan. No. 1 of this series, covering the literature for 1949–1950, appeared in March, 1952. It is divided into the fields of Zoology, Botany, Genetics, and Applied Biology, with a list giving author, title, and reference for the biological subjects published in the leading journals, plus abstracts of the more important papers. The entire journal is in English and comprises 2,285 titles in 93 pages. An additional 93 pages is devoted to abstracts of 365 of these papers, of which 69 are devoted to zoology, 133 to botany, 67 to genetics, and 96 to applied biology (which includes hydrobiology and fisheries). An asterisk after the listed title denotes that there is an abstract. It is planned to publish the review annually.

Recent doctorate degrees from Cornell University's Conservation Department under EDWARD C. RANEY are as follows: ROBERT D. ROSS; thesis "The subspecies and races of the cyprinid fish *Campostoma anomalum* (Rafinesque) in eastern United States"; now associate professor, Biology Department, Virginia Polytechnic Institute, Blacksburg, Virginia. ROLAND L. WIGLEY; thesis "The life history of the sea lamprey, *Petromyzon marinus* Linnaeus, of Cayuga Lake, New York"; now employed as aquatic biologist by the New Jersey Game and Fish Commission. MAX K. HECHT; thesis "A review of the salamander genus *Necturus* Rafinesque"; now of the Zoology Department, Queens College, New York.

Word has been received of the death, on December 4, 1952, of DR. ALFRED WELLER, fishery biologist at the Institut für Fischereiwissenschaft, Hamburg, Germany.

The staff of the Department of Ichthyology of the Academy of Natural Sciences of Philadelphia comprises HENRY W. FOWLER, Curator; ROBERT R. HARRY, Assistant Curator; CHARLES C. G. CHAPLIN, Associate; JANET CANNING, Illustrator; and a secretary and two assistants.

DR. FRANK T. KNAPP, formerly with Texas A. and M. College, is now Chief Marine Biologist, State of Georgia, Marine Laboratory, Brunswick, Georgia.

At the University of California, Los Angeles, contracts are being let for a new Life Sciences Building, to cost nearly $3,000,000. This building will provide much better facilities for the herpetological work under DR. RAYMOND B. COWLES and for the fish and fisheries unit under DR. BOYD W. WALKER who is chairman of the Zoology Department's new building committee.

The Linnaean Society of New York, % American Museum of Natural History, N. Y. 24, N. Y. is disposing of some of its back publications, which include a few on herpetology and ichthyology, at reduced prices. A price list will be sent upon request.

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